ANNUAL FORECAST VERIFICATION STATISTICS

1998

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Introduction

This collection of tables and figures contains series of statistics compiled from the results of routine verification over many years. Some of the statistics have been obtained by verifying the products of the numerical weather prediction model in operational use at the time: others have come from the verification of forecasts made by the staff of the National Meteorological Centre (NMC) formerly Central Forecasting Office (CFO), and the outstations.

A brief summary of the NWP models used operationally in the Met Office is given below:

Nov 1965-Jul. 1972	3-level Model	
Aug 1972-Aug. 1982	10-level Model ('Octagon'	and 'Rectangle'}
Sep 1982-May 1991	15-level Model ('Coarse-Mesh'	and 'Fine-Mesh'}
Jun 1991-	Unified Model ('Global'	and 'Limited Area')
Dec 1992-	Unified Model ('Mesoscale')	
Jan 1998-	High resolution version of Global model implemented.	
Apr 1998-	High resolution Prelim Global model replaced the Limited Area model.	
Jun 1998-	High resolution version of Mesoscale model implemented.	

The following areas have been used for verification:

Northern Hemisphere	90°N - 30°N
Tropics	30°N - 30°S
Southern Hemisphere	30°S - 90°S
Area 2	W.Canada to Europe (See Figure 1)
48-points	U.K. (see Figure 2)

The Tables

Results from verification involving only computer-generated forecasts are presented in Tables 1 to 9. In Table 10 the hand-drawn analyses in NMC have been used to verify both machine and man-made forecasts. Verification results from the wave prediction models are presented in Tables 11 and 12. Please note that the results of subjective verification schemes previously held in Tables 11 and 12 (London precipitation and BBC radio 4 forecasts) have been discontinued from 1998.

Throughout the tables results are given in units of metres (heights and wave heights), hPa (pmsl), knots (winds) and seconds (wave periods). Persistence errors are preceded by a solidus "/". The use of asterisks indicates missing data. The terms 'Global' and 'Limited Area' are used generically to indicate the resolution of the model in use at the time.

The verification statistics presented in Table 1 have been derived using the best available observations, either radiosondes for the upper-air or synops and ships for the surface, while those in Tables 2 to 5 are based on comparisons with model analyses.

Table 6 presents verification of precipitation forecasts from the Limited Area Model against selected reporting stations in the UK for the past year. Table 7 gives verification scores calculated from these results back to 1988. Please note that from 1998 the Limited Area precipitation verification is for the 06Z Forecast run only, giving a direct comparison with the corresponding Mesoscale results. Also, from 1998, only the UK area results are presented, up to T+30.

Table 8 presents verification of precipitation forecasts from the Mesoscale Model for the past year. Table 9 gives verification scores back to 1993 calculated from these results, and other verification statistics derived using surface observations.

Table 10 presents verification of NMC and model forecasts for the 6x8 array of points shown in Figure 2. This array is a legacy from the original grid of the 3-level model (see, for example, Meteorological Office Scientific Paper No 9) and the verification of the NMC forecast by this scheme (Table 10(a)) provides the longest run of verification statistics, back to 1957. Heights at 1000hPa and the implied geostrophic winds are verified against values extracted from the hand-drawn analyses in NMC.

Tables 11 and 12 present results from verification of the Global and European Wave Models respectively. The results given are averages over all observing stations. Wave height and wave period statistics are given. Forecasts of wind speed from the NWP models are used to drive the wave models, and so verification of wind speed is also given.

A summary of the tables is given below:

Table 1	GM verification against observations -	Area 2	(1978-1998)	(Page 4)
Table 2	GM verification against analyses -	Area 2	(1967-1998)	(Page 7)
Table 3	GM verification against analyses -	N.H.	(1984-1998)	(Page10)
Table 4	GM verification against analyses -	Tropics	(1984-1998)	(Page13)
Table 5	GM verification against analyses -	S.H.	(1984-1998)	(Page14)
Table 6	LAM rainfall verification - tables		(1998)	(Page17)
Table 7	LAM rainfall verification - scores		(1988-1998)	(Page18)
Table 8	MESM rainfall verification		(1998)	(Page19)
Table 9	MESM verification against observations		(1993-1998)	(Page20)
Table 10	GM, LAM and NMC 48-point scheme		(1957-1998)	(Page21)
Table 11	Global Wave Model verification		(1988-1998)	(Page26)
Table 12	European Wave Model verification		(1988-1998)	(Page27)

(GM refers to Global Model, LAM to Limited Area Model, MESM to Mesoscale Model)

The Figures

A selection of the statistics given in the tables is also presented graphically in the form of time-series. A summary is given below:

Figure 3	Verification against observations - Area 2 a) rms error of PMSL b) mean error of PMSL	(Page28)
Figure 4	Verification against analyses - Area 2 a) rms error of 500 hPa geopotential height b) mean error of 500 hPa geopotential height	(Page29)
Figure 5	Verification against analyses - Area 2 a) rms vector wind error at 500 hPa b) rms vector wind error at 200 hPa	(Page30)
Figure 6	Verification against analyses - Northern Hemisphere a) rms error of PMSL b) rms vector wind error at 200 hPa	(Page31)
Figure 7	Verification against analyses - Tropics a) rms vector wind error at 850 hPa b) rms vector wind error at 200 hPa	(Page32)
Figure 8	Verification against analyses - Southern Hemisphere a) rms error of PMSL b) rms vector wind error at 200 hPa	(Page33)
Figure 9	48-point verification (NMC v. Global v. Limited Area) a) rms error of 1000 hPa geopotential height b) rms vector wind error at 1000 hPa c) 1000 hPa height change correlation d) 1000 hPa wind stretch vector correlation	(Page38)

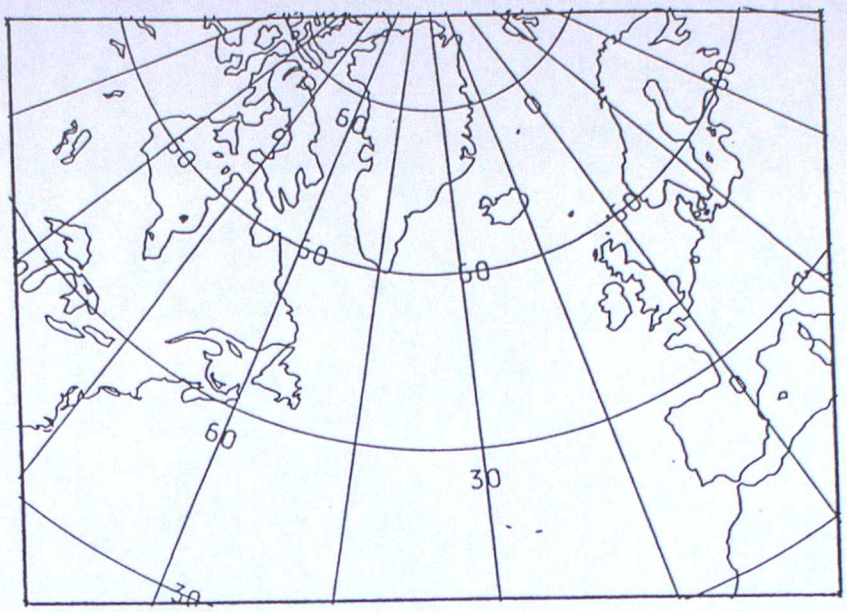

Figure 1. Area 2

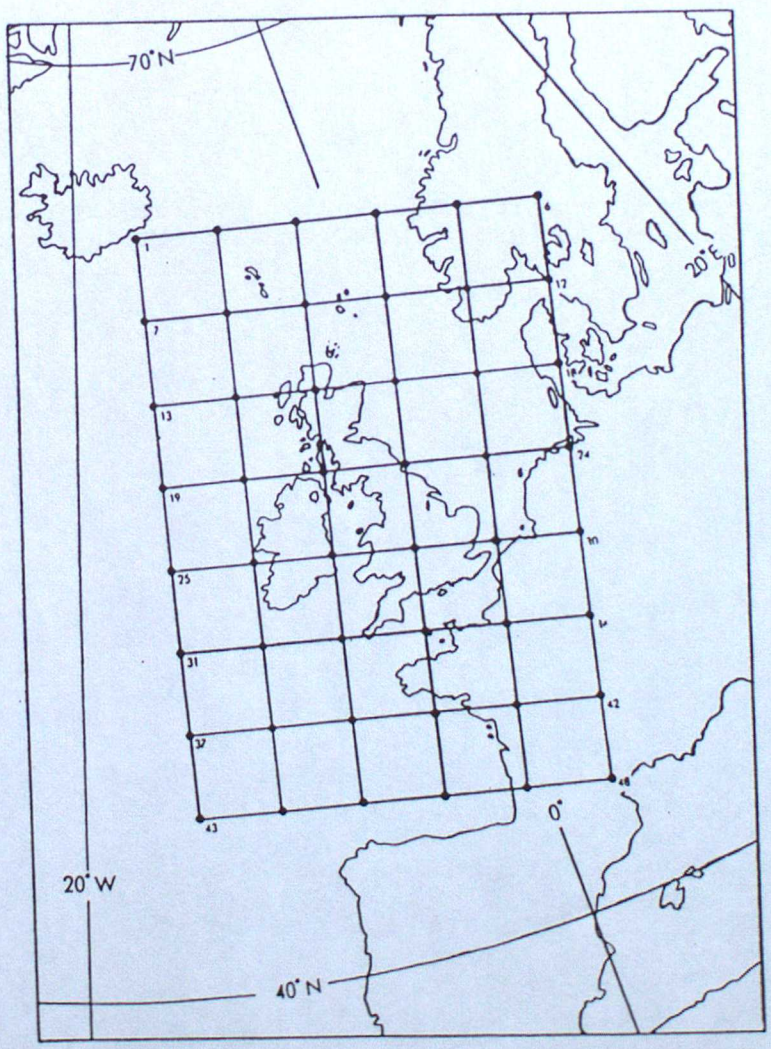

Figure 2. 48-Point Verification Area

TABLE 1: ANNUAL MEAN STATISTICS FOR AREA 2

VERIFICATION AGAINST OBSERVATIONS

	ANALYSES			24-HR F/C			48-HR F/C			72-HR F/C		
	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL
1978	32	15	15	51	35	38	76	57	56	88	79	74
1979	32	16	14	50	34	35	75	57	55	87	79	74
1980	30	16	14	47	33	34	70	55	53	82	77	70
1981	28	15	14	47	34	35	70	56	55	86	75	72
1982	30	17	19	44	32	35	65	51	53	82	73	71
1983	30	20	17	41	30	31	60	48	48	78	72	69
1984	26	18	18	37	28	30	55	47	47	81	69	66
1985	25	16	17	35	26	29	50	42	43	71	61	59
1986	28	16	16	37	26	28	52	40	42	70	55	55
1987	28	17	17	37	25	28	52	40	41	72	58	56
1988	28	17	22	36	25	31	50	40	43	70	57	57
1989	28	17	17	36	26	27	51	41	40	72	58	54
1990	26	17	17	35	26	27	50	41	41	71	57	55
1991	27	16	16	38	25	26	55	39	40	77	57	55
1992†	27	16	15	43	25	26	60	39	39	79	55	53
1993	22	14	14	34	22	24	50	36	37	71	54	52
1994	24	14	14	34	22	23	49	37	37	66	53	52
1995	21	13	13	29	20	21	42	31	33	59	47	47
1996	18	12	11	25	18	19	37	29	29	52	43	40
1997	17	12	11	25	19	18	36	29	29	51	42	41
1998	17	12	11	24	17	18	34	27	27	49	40	39

Table 1(a) Rms errors of the forecast for geopotential height at 200 and 500 hPa (H200 and H500, in metres) and PMSL (in tenths of hPa). († 1992 values are for the 12-month period Nov'91-Oct'92) (Also see graph in Figure 3a)

	ANALYSES			24-HR F/C			48-HR F/C			72-HR F/C		
	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL
1978	-2	1	0	-5	-2	6	-15	-8	1	-20	-9	3
1979	-1	1	0	-8	-4	5	-18	-10	-1	-24	-11	1
1980	0	1	-1	-3	-2	5	-10	-7	-2	-13	-6	-2
1981	0	2	-1	-3	-2	5	-10	-8	-2	-15	-9	-1
1982	-4	-1	-1	-6	-3	0	-12	-8	-4	-20	-12	-7
1983	-12	-10	0	-10	-13	-4	-20	-23	-12	-34	-35	-23
1984	-10	-10	3	-10	-12	0	-18	-22	-8	-30	-33	-18
1985	-6	-6	2	-6	-9	2	-12	-16	-3	-18	-22	-4
1986	1	-2	1	0	-6	0	-6	-12	-4	-10	-14	-3
1987	3	-2	2	1	-7	4	-9	-17	-2	-19	-25	-4
1988	2	-2	1	-1	-7	2	-8	-13	-1	-14	-17	-2
1989	0	-4	0	-5	-8	1	-11	-15	-1	-17	-19	-1
1990	-2	-5	0	-7	-10	0	-13	-15	-1	-19	-20	-1
1991	-9	-6	0	-19	-10	0	-28	-14	-1	-37	-17	-3
1992†	-13	-6	0	-29	-12	1	-41	-15	0	-48	-16	1
1993	-7	-2	1	-19	-8	-1	-28	-14	-4	-36	-18	-4
1994	-7	-2	1	-19	-9	-2	-29	-16	-6	-33	-18	-7
1995	-6	-2	1	-13	-2	4	-18	-4	4	-20	-3	5
1996	-3	-1	0	-8	1	4	-11	1	5	-12	2	6
1997	-4	-1	-1	-9	0	4	-11	2	7	-11	3	9
1998	-3	-0	1	-7	-1	3	-10	-1	4	-12	-1	4

Table 1(b) Mean errors of the forecast for geopotential height at 200 and 500 hPa (H200 and H500, in metres) and PMSL (in tenths of hPa). († 1992 values are for the 12-month period Nov'91-Oct'92) (Also see graph in Figure 3b)

	ANALYSES		24-HR F/C		48-HR F/C		72-HR F/C	
	W200	W500	W200	W500	W200	W500	W200	W500
1978	12	11	17	15	23	20	28	24
1979	12	11	17	15	23	20	28	25
1980	12	11	17	15	22	19	27	24
1981	12	11	17	15	22	20	27	24
1982	11	10	16	15	21	19	26	23
1983	8	7	15	13	19	17	25	22
1984	8	7	14	13	19	17	24	22
1985	9	8	14	13	18	17	22	21
1986	9	8	14	13	18	16	22	20
1987	9	8	13	12	18	16	22	20
1988	9	8	13	12	17	16	22	20
1989	10	8	13	12	17	16	22	20
1990	9	8	13	12	17	16	22	20
1991	9	8	12	11	17	15	22	20
1992†	8	8	12	12	16	16	22	20
1993	8	7	12	11	16	15	21	20
1994	8	7	12	11	16	15	21	19
1995	8	7	11	11	15	14	20	19
1996	8	8	11	11	14	14	18	18
1997	8	7	11	11	15	14	19	18
1998	8	7	11	10	14	13	18	17

Table 1(c) Rms vector wind errors of the forecasts at 200 and 500 hPa (W200 and W500) in knots.
(† 1992 values are for the 12-month period Nov'91-Oct'92)

	ANALYSES			24-HR FORECAST			48-HR FORECAST		
	T200	T500	SURF	T200	T500	SURF	T200	T500	SURF
1978	2.9	1.5	4.6	3.6	1.9	4.3	4.6	2.7	4.9
1979	2.9	1.5	4.4	3.7	1.9	4.2	4.7	2.7	4.8
1980	2.9	1.4	4.3	3.7	1.9	4.1	4.7	2.6	4.6
1981	2.8	1.4	4.3	3.6	1.9	4.0	4.5	2.7	4.5
1982	2.5	1.3	3.9	3.3	1.8	4.0	4.1	2.5	4.5
1983	1.8	0.9	2.8	2.7	1.7	3.6	3.2	2.3	3.9
1984	1.8	0.9	2.7	2.5	1.6	3.2	3.2	2.3	3.6
1985	1.8	0.9	2.9	2.5	1.6	3.3	3.0	2.2	3.7
1986	1.9	0.9	2.9	2.5	1.6	3.2	3.1	2.2	3.6
1987	1.9	1.0	2.8	2.5	1.6	3.2	3.1	2.2	3.6
1988	1.9	1.0	2.9	2.5	1.6	3.3	3.1	2.2	3.6
1989	2.0	1.1	2.9	2.5	1.6	3.2	3.0	2.2	3.5
1990	1.9	1.1	2.9	2.4	1.6	3.2	3.0	2.2	3.5
1991	1.6	1.0	2.8	2.2	1.5	3.1	2.8	2.0	3.4
1992†	1.6	1.0	2.7	2.1	1.5	2.9	2.7	2.1	3.2
1993	1.4	0.9	2.7	2.0	1.3	3.0	2.6	1.9	3.3
1994	1.4	0.9	2.8	2.0	1.3	2.9	2.7	1.9	3.2
1995	1.4	0.9	2.7	2.0	1.3	2.8	2.5	1.8	3.0
1996	1.3	0.8	2.8	1.9	1.2	2.9	2.4	1.7	3.2
1997	1.4	0.8	2.7	1.9	1.2	2.9	2.4	1.7	3.1
1998	1.3	0.8	2.5	1.8	1.2	2.8	2.2	1.6	3.1

Table 1(d) Rms errors of the forecasts of temperature at 200 and 500 hPa (T200 and T500) and at 1.5m above the surface (SURF), all in degrees K.
(† 1992 values are for the 12-month period Nov'91-Oct'92)

	ANALYSES			24-HR FORECAST			48-HR FORECAST		
	T200	T500	SURF	T200	T500	SURF	T200	T500	SURF
1978	-1.2	-0.2	-0.2	-1.7	-0.1	-1.0	-2.2	-0.1	-1.2
1979	-1.1	-0.3	-0.3	-1.8	-0.2	-1.2	-2.3	-0.1	-1.5
1980	-1.3	-0.3	-0.1	-1.9	-0.1	-1.2	-2.5	0.1	-1.4
1981	-1.1	-0.2	0.0	-1.6	-0.1	-1.1	-2.0	0.0	-1.4
1982	-0.6	-0.2	0.0	-0.9	-0.1	-0.4	-1.2	-0.1	-0.5
1983	0.3	-0.3	-0.6	0.5	-0.3	-0.1	0.5	-0.4	-0.1
1984	0.3	-0.3	-0.8	0.4	-0.3	-0.7	0.3	-0.4	-0.8
1985	0.2	-0.3	-0.7	0.3	-0.3	-0.6	0.2	-0.4	-0.6
1986	0.5	-0.2	-0.9	0.6	-0.3	-0.7	0.6	-0.4	-0.7
1987	0.6	-0.3	-1.1	0.8	-0.4	-1.0	0.8	-0.6	-1.1
1988	0.5	-0.2	-0.8	0.6	-0.3	-0.8	0.6	-0.4	-0.9
1989	0.5	-0.2	-0.8	0.5	-0.4	-0.8	0.5	-0.6	-0.9
1990	0.4	-0.2	-0.9	0.4	-0.4	-0.9	0.4	-0.6	-0.9
1991	0.4	-0.2	-0.7	0.4	-0.4	-0.7	0.2	-0.5	-0.7
1992†	0.2	-0.2	-0.9	0.3	-0.5	-1.0	0.2	-0.7	-1.1
1993	0.3	-0.1	-1.0	0.5	-0.2	-1.3	0.5	-0.3	-1.4
1994	0.2	-0.1	-1.2	0.5	-0.3	-1.2	0.6	-0.3	-1.3
1995	0.2	-0.1	-0.9	0.4	-0.2	-1.0	0.4	-0.2	-1.1
1996	0.2	-0.1	-1.2	0.4	-0.2	-1.2	0.4	-0.2	-1.3
1997	0.3	-0.1	-1.3	0.5	-0.2	-1.3	0.5	-0.2	-1.4
1998	0.3	-0.0	-1.1	0.5	-0.1	-1.3	0.5	-0.1	-1.5

Table 1(e) Mean errors of the forecasts of temperature at 200 and 500 hPa (T200 and T500) and at 1.5m above the surface (SURF), all in degrees K. († 1992 values are for the 12-month period Nov'91-Oct'92)

TABLE 2: ANNUAL MEAN STATISTICS FOR AREA 2

VERIFICATION AGAINST ANALYSES

	24-HR FORECAST			48-HR FORECAST			72-HR FORECAST		
	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL
1967	54/***	42/**	44/**	97/***	76/***	73/***			
1968	51/***	42/**	44/**	90/***	72/***	73/***			
1969	50/***	42/**	42/**	86/***	71/***	71/***			
1970	50/***	43/**	43/**	86/***	71/***	72/***			
1971	54/***	45/**	44/**	91/***	77/***	75/***			
1972	54/***	44/**	45/**	96/***	75/***	75/***			
1973	50/ 84	39/73	43/72	87/126	68/107	70/ 98	120/144	94/123	89/108
1974	53/ 89	41/74	42/71	93/130	70/105	67/ 93	131/151	97/121	87/103
1975	53/ 94	41/78	41/72	90/137	69/112	65/ 97	125/159	94/128	84/108
1976	54/ 97	42/80	41/75	91/140	69/112	65/100	125/159	93/127	84/109
1977	54/ 99	40/81	39/72	83/145	65/116	61/ 98	112/168	88/134	79/110
1978	46/102	36/82	38/75	73/146	58/114	57/100	99/167	79/130	74/111
1979	45/ 99	35/81	36/74	71/146	58/116	54/100	98/169	80/133	74/112
1980	42/ 99	34/82	35/77	67/141	56/114	53/103	94/161	77/130	70/112
1981	42/100	34/83	36/75	68/145	56/116	54/101	95/165	76/131	71/110
1982	41/100	33/83	35/80	63/143	52/115	52/105	89/166	72/131	71/114
1983	36/ 98	27/80	34/81	55/144	43/114	50/108	79/168	63/130	69/119
1984	31/ 94	24/78	31/77	50/140	41/111	47/103	74/163	62/129	65/116
1985	30/ 94	23/78	29/77	48/138	40/111	44/104	70/161	59/129	60/116
1986	28/ 98	22/79	28/80	48/140	38/109	42/104	70/158	54/123	56/113
1987	28/ 95	22/76	26/77	49/140	39/108	42/102	72/163	57/125	57/112
1988	26/ 99	21/81	26/80	46/140	37/115	41/106	68/166	55/131	56/115
1989	25/100	19/80	24/82	46/143	36/111	40/106	69/164	55/128	56/116
1990	25/102	19/81	24/82	45/148	36/114	40/109	68/167	54/129	56/119
1991	26/ 97	18/78	22/78	47/143	35/110	38/103	70/165	54/127	55/113
1992	28/ 91	19/78	22/76	50/135	35/111	37/101	71/158	53/128	53/112
1993	24/ 91	17/76	20/75	43/136	33/107	35/100	64/158	51/125	51/111
1994	24/ 95	17/78	21/76	41/138	32/111	35/102	61/158	50/125	51/113
1995	20/ 92	15/75	18/75	36/137	29/108	31/103	55/160	45/126	45/115
1996	19/ 93	15/75	17/74	34/139	28/109	29/106	52/163	44/127	43/112
1997	19/ 94	14/75	17/75	32/138	27/108	29/100	50/160	43/125	43/111
1998	17/ 88	13/70	16/70	30/130	25/102	28/ 96	46/154	40/120	40/107

Table 2(a) Rms errors of the forecast and persistence for geopotential height at 200 and 500 hPa (H200 and H500, in metres) and PMSL (in tenths of hPa).
(Also see graph in Figure 4a)

	24-HR FORECAST			48-HR FORECAST			72-HR FORECAST		
	H200	H500	PMSL	H200	H500	PMSL	H200	H500	PMSL
1973	14/**	4/**	-2/**	23/**	5/**	-9/**	32/**	5/**	-18/**
1974	23/**	10/**	3/**	40/**	15/**	-1/**	55/**	19/**	-7/**
1975	25/**	11/**	3/**	43/**	15/**	-3/**	57/**	18/**	-11/**
1976	27/ 1	13/ 0	6/ 0	43/-1	18/ 0	1/ 0	57/-2	22/ 0	-6/ 0
1977	27/ 0	14/ 0	9/ 0	35/ 0	14/ 0	0/ 0	41/-1	14/ 0	-6/ 0
1978	-1/ 0	1/ 0	8/ 0	-11/ 0	-2/ 0	5/ 0	-14/-1	0/ 0	7/ 0
1979	-4/ 0	-1/ 0	6/ 0	-15/-1	-5/ 0	1/ 0	-19/-1	-4/ 0	2/ 0
1980	0/ 0	-1/ 0	7/ 0	-9/ 1	-5/ 0	2/ 0	-13/ 1	-4/ 0	3/ 0
1981	0/ 0	-1/ 0	7/ 0	-10/ 0	-6/ 0	2/ 1	-14/ 0	-6/ 1	3/ 2
1982	-3/ 0	-2/ 0	2/ 0	-10/ 1	-4/ 1	-2/ 0	-15/ 1	-6/ 1	-4/ 1
1983	-1/ 1	-3/ 1	-2/ 1	-9/ 2	-10/ 1	-9/ 2	-18/ 2	-17/ 2	-18/ 3
1984	0/ 0	-3/ 0	-1/ 0	-8/-1	-10/-1	-7/ 0	-18/-2	-19/-1	-15/ 0
1985	-1/-8	-2/ 0	1/-7	-9/-5	-9/ 0	-2/-7	-17/-3	-14/ 0	-4/-7
1986	-3/-1	-3/ 0	1/ 0	-10/-1	-8/-1	-1/-1	-15/-1	-11/-1	-2/-1
1987	-3/-1	-3/ 0	3/ 0	-13/-1	-9/-1	0/-1	-22/-1	-15/-1	-2/-1
1988	-4/ 0	-3/ 0	3/ 0	-13/ 0	-9/ 0	1/ 0	-22/ 1	-15/ 1	-2/ 0
1989	-7/ 0	-4/ 0	2/ 0	-14/-1	-9/-1	0/ 0	-20/-1	-14/-1	-2/ 0
1990	-7/ 0	-5/ 0	1/ 0	-14/ 1	-9/ 0	0/ 0	-20/ 1	-13/ 0	-2/ 0
1991	-12/ 0	-4/ 0	1/ 0	-22/ 0	-7/ 0	1/-1	-30/ 0	-10/ 0	0/ 0
1992	-17/ 0	-6/ 0	0/ 0	-29/ 1	-9/ 0	0/ 0	-37/ 1	-10/ 1	0/ 0
1993	-14/ 0	-6/ 0	-1/ 0	-23/ 0	-10/ 0	-2/ 0	-30/ 0	-13/ 0	-3/ 0
1994	-14/ 0	-6/ 0	-2/ 0	-22/ 0	-10/ 0	-4/ 0	-27/ 0	-13/ 0	-7/ 0
1995	-9/ 0	-1/ 0	2/ 0	-13/ 1	-2/ 0	4/ 0	-16/ 1	-1/ 0	5/ 0
1996	-6/ 0	1/ 0	3/-3	-9/ 0	2/ 0	5/-6	-11/-1	2/ 0	5/-9
1997	-7/ 0	0/ 0	2/ 4	-7/ 0	3/ 0	6/ 8	-7/ 0	5/ 0	8/11
1998	-5/ 0	0/ 0	2/ 0	-7/ 0	1/ 0	4/ 0	-8/ 0	1/ 0	4/ 0

Table 2(b) Mean errors of the forecast and persistence for geopotential height at 200 and 500 hPa (H200 and H500, in metres) and PMSL (in tenths of hPa). (Also see graph in Figure 4b)

	24-HR FORECAST			48-HR FORECAST			72-HR FORECAST		
	W200	W500	SURF	W200	W500	SURF	W200	W500	SURF
1967	21/**	17/**		31/**	25/**				
1968	20/**	17/**		29/**	25/**				
1969	19/**	17/**		29/**	25/**				
1970	20/**	18/**		29/**	26/**				
1971	20/**	19/**		30/**	27/**				
1972	21/**	18/**		29/**	26/**				
1973	16/27	15/25		23/36	22/32		29/39	27/35	
1974	16/28	15/25		23/37	21/31		29/40	27/34	
1975	17/29	16/27		24/38	22/34		30/41	28/36	
1976	17/30	16/27		23/39	22/33		30/41	26/35	
1977	16/31	14/27	7/12	22/40	19/34	9/15	27/43	24/37	11/16
1978	16/31	14/28	7/12	22/40	19/34	9/14	27/43	23/37	11/15
1979	16/31	14/27	7/12	21/40	19/35	9/14	27/44	24/37	11/15
1980	15/31	13/28	6/13	20/39	18/34	8/15	26/42	23/36	10/16
1981	15/31	13/28	7/12	21/41	18/35	9/15	26/43	23/37	10/15
1982	16/33	14/29	8/14	20/41	19/36	9/16	26/45	23/38	11/17
1983	16/35	14/31	8/15	20/44	18/37	10/17	25/48	22/39	11/18
1984	14/34	13/29	7/13	19/43	17/35	9/15	24/46	21/38	10/16
1985	14/33	13/29	6/12	18/41	16/35	8/14	23/44	23/37	9/14
1986	13/34	11/29	7/13	17/42	15/34	8/15	22/44	22/36	10/16
1987	12/32	11/27	7/14	17/41	15/33	9/16	22/45	22/36	11/17
1988	11/33	10/28	6/14	16/42	14/35	8/16	21/44	21/36	10/16
1989	10/32	8/27	6/14	15/40	13/32	8/15	20/43	18/35	10/16
1990	10/33	8/27	5/13	15/42	13/34	8/15	21/44	18/35	10/16
1991	10/32	8/27	5/13	15/41	13/33	7/15	21/45	18/35	10/15
1992	10/31	8/27	5/13	16/40	13/33	7/15	21/43	19/36	9/15
1993	10/32	8/27	5/13	15/41	13/33	7/15	20/44	18/35	9/16
1994	10/33	8/27	5/13	15/42	13/33	7/15	20/45	18/35	9/16
1995	9/32	7/26	4/13	14/41	12/32	6/15	19/44	17/34	8/16
1996	8/32	7/26	4/12	13/42	12/33	6/15	18/46	16/36	8/16
1997	8/32	7/27	4/13	13/41	11/33	6/15	18/46	16/36	8/16
1998	8/32	7/25	4/13	13/41	11/31	6/15	18/44	16/34	8/15

Table 2(c) Rms vector wind errors of the forecast and persistence at 200 and 500 hPa (W200 and W500) and at 10m above the surface (SURF), all in knots. (Also see graphs in Figures 5a and 5b)

TABLE 3: ANNUAL MEAN STATISTICS FOR THE NORTHERN HEMISPHERE

VERIFICATION AGAINST ANALYSES

	T+24	T+48	T+72	T+96	T+120	T+144
1984	34/70	50/94	65/105	80/110	93/114	106/115
1985	32/70	45/95	58/105	71/107	82/109	91/110
1986	30/72	43/95	56/103	69/109	80/112	91/114
1987	29/69	42/93	55/103	69/109	78/113	88/116
1988	28/71	41/95	54/104	67/109	78/112	87/115
1989	24/70	39/94	53/103	66/110	77/115	87/118
1990	24/71	39/96	52/105	66/111	78/115	87/117
1991	23/69	38/93	52/102	65/108	78/112	89/116
1992	22/67	38/91	52/101	64/106	77/109	88/112
1993	22/68	36/91	49/101	62/106	75/109	86/112
1994	22/67	35/91	48/100	61/111	75/112	87/112
1995	18/66	30/91	42/102	55/108	67/112	79/115
1996	19/68	31/95	43/106	52/113	67/116	80/119
1997	18/68	30/93	42/103	54/109	67/112	79/115
1998	18/66	28/89	40/ 98	52/104	66/109	78/112

Table 3(a) Rms errors of the forecast and persistence for PMSL (in tenths of hPa).
(Also see graph in Figure 6a)

	T+24	T+48	T+72	T+96	T+120	T+144
1984	-1	-5	-9	-11	-11	-14
1985	0	-2	-3	-3	-2	-3
1986	1	-2	-3	-3	-3	-3
1987	1	0	0	0	1	0
1988	0	0	0	-1	-1	-2
1989	1	1	1	1	2	2
1990	1	2	1	1	2	1
1991	0	-1	-1	-1	-1	-2
1992	-3	-4	-4	-3	-4	-4
1993	-2	-4	-4	-4	-4	-5
1994	-3	-5	-5	-5	-6	-6
1995	1	0	1	3	4	4
1996	1	1	3	5	6	6
1997	1	2	3	5	5	7
1998	0	-1	1	3	2	3

Table 3(b) Mean errors of the forecast for PMSL (in tenths of hPa).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	25/68	40/ 96	57/112	74/120	90/125	103/128
1985	23/68	38/ 98	53/114	68/117	82/120	93/122
1986	22/70	36/ 98	51/111	66/120	79/127	91/132
1987	21/67	36/ 96	50/111	65/121	79/127	92/131
1988	21/70	35/ 99	51/113	66/122	80/128	92/133
1989	18/68	33/ 98	49/113	65/123	79/130	91/135
1990	18/68	33/ 98	48/111	63/119	78/126	90/130
1991	17/67	32/ 96	48/110	64/121	80/128	94/133
1992	17/66	32/ 95	47/110	62/118	78/124	91/127
1993	16/66	30/ 95	45/109	61/117	77/123	92/128
1994	16/67	29/ 96	44/109	60/118	77/124	92/128
1995	14/64	26/ 94	39/109	54/120	69/127	83/131
1996	14/67	27/ 98	41/115	56/125	71/131	86/136
1997	14/66	26/ 96	39/111	54/121	70/128	84/133
1998	13/64	25/ 91	38/106	53/116	68/123	83/127

Table 3(c) Rms errors of the forecast and persistence for geopotential height at 500 hPa (in metres).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	-3	-9	-13	-16	-18	-21
1985	-3	-8	-12	-14	-16	-18
1986	-4	-8	-10	-12	-14	-15
1987	-4	-8	-11	-14	-16	-19
1988	-5	-10	-13	-17	-20	-23
1989	-4	-8	-11	-13	-15	-18
1990	-4	-7	-10	-13	-15	-18
1991	-3	-5	-7	-9	-10	-12
1992	-6	-8	-9	-9	-10	-11
1993	-5	-8	-10	-11	-13	-14
1994	-5	-8	-9	-10	-11	-12
1995	-1	-2	-1	0	0	0
1996	0	0	1	3	3	3
1997	0	0	2	3	3	4
1998	-1	-1	0	1	1	2

Table 3(d) Mean errors of the forecast for geopotential height at 500 hPa (in metres).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	12/20	15/23	17/24	19/25	21/25	23/25
1985	12/20	14/23	16/24	19/24	20/24	21/25
1986	11/20	14/23	16/24	18/25	19/25	21/25
1987	10/19	13/22	15/23	17/24	19/24	20/25
1988	9/19	12/22	15/23	16/23	18/24	20/24
1989	8/18	11/21	13/22	16/23	18/23	19/24
1990	8/18	11/21	13/22	16/23	18/23	19/23
1991	7/17	10/21	13/22	16/22	18/23	20/23
1992	7/17	9/20	13/21	15/22	18/22	19/23
1993	6/17	9/21	12/22	15/22	17/22	19/23
1994	6/17	9/20	12/21	15/22	19/23	19/23
1995	5/16	8/20	11/21	14/22	16/22	18/22
1996	5/17	8/20	11/21	14/22	16/23	18/23
1997	5/17	8/20	11/21	14/22	16/23	18/23
1998	5/17	8/20	11/21	14/22	16/22	18/22

Table 3(e) Rms vector wind errors of the forecast and persistence at 850 hPa (in knots).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	15/31	19/40	24/43	29/44	33/45	36/46
1985	15/31	19/39	23/43	28/43	31/43	34/44
1986	14/32	18/40	22/42	26/44	30/45	34/46
1987	13/30	17/39	22/42	26/44	30/46	33/47
1988	12/31	17/40	21/43	26/44	30/45	33/46
1989	10/29	15/38	20/41	25/44	29/45	33/46
1990	10/30	15/39	20/42	25/43	29/45	32/45
1991	10/30	15/38	21/41	26/43	30/44	34/45
1992	10/29	15/37	20/41	25/42	30/43	34/44
1993	10/30	15/39	20/41	25/43	29/44	34/45
1994	10/30	15/39	20/42	25/44	30/45	35/46
1995	9/30	14/39	19/42	24/44	29/45	33/46
1996	9/30	13/39	18/43	23/45	28/46	32/47
1997	8/30	13/39	18/42	23/44	28/45	32/46
1998	8/31	13/39	18/42	23/44	28/45	32/46

Table 3(f) Rms vector wind errors of the forecast and persistence at 200 hPa (in knots).
(Also see graph in Figure 6b)

TABLE 4: ANNUAL MEAN STATISTICS FOR THE TROPICS

VERIFICATION AGAINST ANALYSES

	T+24	T+48	T+72	T+96	T+120	T+144
1984	11/12	12/15	13/15	14/16	14/16	15/16
1985	10/12	12/15	13/15	14/15	14/16	14/17
1986	10/12	11/15	12/16	13/16	14/16	14/16
1987	9/11	11/13	11/14	12/15	13/15	13/15
1988	9/11	10/13	11/14	12/14	12/14	13/15
1989	7/ 9	9/11	10/12	11/13	12/13	12/13
1990	7/ 9	9/12	10/13	11/13	12/14	12/14
1991	6/ 8	8/11	10/12	11/13	11/13	12/13
1992	5/ 8	7/11	9/12	10/12	11/13	12/13
1993	5/ 8	7/10	8/12	9/12	10/12	11/13
1994	5/ 8	7/11	8/12	9/12	10/12	11/12
1995	4/ 7	6/10	7/11	9/11	9/11	10/12
1996	5/ 8	6/11	8/12	9/12	10/13	11/13
1997	4/ 8	6/10	7/11	8/12	9/12	10/12
1998	5/ 8	6/11	8/12	9/12	10/12	10/12

Table 4(a) Rms vector wind errors of the forecast and persistence at 850 hPa (in knots).
(Also see graph in Figure 7a)

	T+24	T+48	T+72	T+96	T+120	T+144
1984	16/21	19/27	22/29	24/30	26/31	27/31
1985	15/21	18/26	21/29	23/30	24/30	26/31
1986	14/20	18/26	20/29	22/30	23/31	25/32
1987	14/19	17/25	19/28	21/29	22/30	24/30
1988	13/19	16/25	18/28	20/29	22/30	23/30
1989	11/16	14/23	17/26	19/27	21/28	23/28
1990	10/16	14/23	17/26	19/28	21/29	23/29
1991	11/18	16/25	19/28	22/29	24/30	26/30
1992	10/17	15/24	18/27	21/28	24/29	26/30
1993	9/17	14/24	17/27	20/28	22/29	24/30
1994	9/17	14/23	17/26	19/28	21/29	24/29
1995	9/17	13/23	17/26	19/28	22/28	24/29
1996	9/18	14/25	17/28	20/29	22/30	24/31
1997	9/17	13/25	16/28	18/29	21/30	23/31
1998	9/19	13/25	16/29	18/30	21/31	23/31

Table 4(b) Rms vector wind errors of the forecast and persistence at 200 hPa (in knots).
(Also see graph in Figure 7b)

TABLE 5: ANNUAL MEAN STATISTICS FOR THE SOUTHERN HEMISPHERE

VERIFICATION AGAINST ANALYSES

	T+24	T+48	T+72	T+96	T+120	T+144
1984	41/81	61/107	76/117	90/121	99/125	108/126
1985	40/84	58/110	73/120	85/122	96/123	105/124
1986	41/85	59/112	74/123	87/130	98/135	106/138
1987	38/83	56/110	70/123	83/129	93/133	100/135
1988	36/81	54/109	68/120	80/126	90/129	98/131
1989	32/84	51/111	67/121	81/128	92/132	100/132
1990	32/84	51/112	67/124	80/130	92/134	102/136
1991	32/82	52/110	69/123	83/130	95/135	106/137
1992	30/81	49/109	66/121	81/127	94/132	105/134
1993	28/83	46/111	63/124	78/131	91/135	102/137
1994	28/81	46/108	62/120	77/125	91/128	102/130
1995	27/80	44/108	60/120	75/126	89/130	100/132
1996	29/83	47/116	65/123	81/129	94/134	106/136
1997	30/84	48/111	65/124	81/131	94/136	106/139
1998	29/88	46/115	63/126	79/132	93/135	104/136

Table 5(a) Rms errors of the forecast and persistence for PMSL (in tenths of hPa). (Also see graph in Figure 8a)

	T+24	T+48	T+72	T+96	T+120	T+144
1984	2	2	3	2	0	0
1985	2	4	3	3	3	5
1986	3	4	3	4	5	7
1987	2	3	3	5	6	9
1988	3	4	4	5	7	10
1989	2	4	5	7	8	11
1990	2	3	4	5	6	7
1991	2	3	3	3	4	4
1992	3	4	3	4	3	3
1993	3	4	4	3	4	4
1994	2	2	1	0	0	0
1995	3	4	3	3	3	4
1996	1	0	-1	-3	-2	-2
1997	1	1	0	-1	-1	-1
1998	1	2	1	1	2	2

Table 5(b) Mean errors of the forecast for PMSL (in tenths of hPa).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	34/80	55/112	72/126	88/132	100/136	111/138
1985	32/81	52/113	69/126	85/128	97/129	108/130
1986	31/82	52/114	70/129	85/138	98/144	108/147
1987	29/82	49/114	65/130	80/137	92/141	101/143
1988	29/81	48/114	65/128	80/136	92/139	102/142
1989	27/86	47/118	65/132	81/140	94/145	104/145
1990	28/85	47/118	65/132	80/140	94/145	105/148
1991	27/83	48/118	67/134	84/144	99/151	111/154
1992	25/84	45/118	65/134	82/142	97/147	111/150
1993	24/86	43/121	62/137	79/147	95/152	108/154
1994	24/85	43/119	61/134	78/141	93/145	107/147
1995	22/85	40/117	59/133	76/141	92/146	107/149
1996	24/89	45/124	65/139	84/148	101/154	114/157
1997	24/87	44/121	63/138	81/148	98/154	112/158
1998	23/90	42/122	61/136	79/145	95/149	109/152

Table 5(c) Rms errors of the forecast and persistence for geopotential height at 500 hPa (in metres).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	-1	-2	-3	-5	-9	-10
1985	-3	-7	-12	-16	-20	-21
1986	-2	-6	-10	-14	-16	-18
1987	-7	-11	-15	-19	-22	-23
1988	-5	-11	-17	-22	-26	-28
1989	-4	-8	-11	-15	-18	-20
1990	-4	-8	-13	-16	-19	-21
1991	-4	-8	-11	-14	-17	-18
1992	-4	-7	-10	-12	-13	-14
1993	-3	-6	-9	-12	-13	-13
1994	-3	-6	-9	-11	-11	-12
1995	-1	-3	-5	-6	-6	-6
1996	-1	-2	-4	-4	-4	-3
1997	-1	-1	-2	-2	-1	0
1998	-1	-2	-3	-4	-3	-2

Table 5(d) Mean errors of the forecast for geopotential height at 500 hPa (in metres).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	12/22	16/25	19/26	21/27	22/27	24/27
1985	12/22	16/25	19/26	21/26	22/27	23/27
1986	12/22	16/26	19/27	21/28	22/28	23/29
1987	11/22	15/25	17/27	19/27	21/27	22/28
1988	11/21	14/25	17/26	19/27	20/27	21/27
1989	8/21	12/25	16/26	18/26	20/27	21/26
1990	8/21	12/25	16/26	18/26	20/27	21/27
1991	8/20	12/24	16/26	19/26	21/27	23/27
1992	7/20	12/24	15/25	18/26	20/26	23/26
1993	7/20	11/24	15/26	18/27	20/27	22/27
1994	7/20	12/24	15/26	18/26	21/26	22/26
1995	7/20	11/24	15/25	18/26	20/26	22/26
1996	7/21	12/24	16/26	19/26	21/27	23/27
1997	7/20	12/24	16/25	19/26	21/27	23/27
1998	7/21	12/25	15/26	18/26	21/27	23/27

Table 5(e) Rms vector wind errors of the forecast and persistence at 850hPa (in knots).

	T+24	T+48	T+72	T+96	T+120	T+144
1984	14/32	20/40	25/43	30/44	33/45	36/45
1985	14/33	20/41	26/43	30/44	33/44	36/44
1986	14/33	20/41	25/44	29/45	33/46	35/47
1987	14/33	20/41	24/45	29/45	32/46	35/47
1988	13/33	19/42	24/46	28/47	31/47	34/47
1989	10/33	17/42	23/45	28/46	32/47	35/47
1990	11/33	17/41	23/44	28/46	31/47	34/47
1991	10/32	17/41	23/45	29/46	33/48	37/48
1992	10/31	16/41	22/44	28/45	33/46	37/47
1993	10/33	16/42	22/46	28/48	33/49	37/49
1994	10/33	16/43	22/46	28/47	33/48	37/48
1995	10/33	16/42	22/45	28/46	33/47	38/48
1996	9/34	16/43	23/47	29/48	34/49	38/49
1997	9/33	15/42	22/46	28/48	33/49	37/49
1998	9/36	16/46	22/48	28/50	34/50	38/50

Table 5(f) Rms vector wind errors of the forecast and persistence at 200hPa (in knots).
(Also see graph in Figure 8b)

TABLE 6: VERIFICATION OF LIMITED AREA MODEL PRECIPITATION FORECAST

FORECAST PERIOD 0-6

FORECAST \ Observed	O	L	M	H	All
O	44.4	5.7	0.4	0.0	50.5
L	21.0	16.6	3.3	0.1	41.0
M	0.8	3.3	3.4	0.4	7.8
H	0.0	0.1	0.2	0.3	0.6
All	66.2	25.7	7.3	0.8	100.0

FORECAST PERIOD 6-12

FORECAST \ Observed	O	L	M	H	All
O	43.6	4.4	0.5	0.0	48.5
L	24.3	14.6	3.4	0.1	42.4
M	1.5	3.2	3.5	0.4	8.5
H	0.0	0.1	0.4	0.2	0.6
All	69.5	22.2	7.7	0.7	100.0

FORECAST PERIOD 12-18

FORECAST \ Observed	O	L	M	H	All
O	44.9	5.7	0.7	0.0	51.3
L	21.6	15.4	3.3	0.1	40.4
M	0.7	3.4	3.2	0.4	7.7
H	0.0	0.1	0.3	0.1	0.5
All	67.3	24.5	7.6	0.7	100.0

FORECAST PERIOD 18-24

FORECAST \ Observed	O	L	M	H	All
O	42.0	5.6	0.6	0.0	48.2
L	24.3	14.6	3.2	0.1	42.2
M	1.4	3.7	3.6	0.3	8.9
H	0.0	0.1	0.4	0.1	0.6
All	67.7	24.0	7.8	0.5	100.0

FORECAST PERIOD 24-30

FORECAST \ Observed	O	L	M	H	All
O	37.3	5.2	0.4	0.1	42.9
L	27.5	16.6	3.3	0.2	47.6
M	1.4	3.8	3.2	0.4	8.8
H	0.0	0.1	0.3	0.2	0.6
All	66.2	25.7	7.3	0.8	100.0

Table 6(a) UK area. Contingency tables for 1998 with frequencies averaged over selected reporting stations and expressed as percentages (06Z run data).
Key to precipitation classes:-
"O" = Nil pptn (less than 0.1 mm), "L" = Light (between 0.1 & 2.4 mm)
"M" = Moderate (between 2.4 & 10.4 mm), "H" = Heavy (10.4 mm or more)

TABLE 7: LIMITED AREA MODEL PRECIPITATION FORECAST SCORES

	FORECAST PERIOD				
	0-6	6-12	12-18	18-24	24-30
1988	77.9	77.0	74.7	74.5	72.4
1989	80.6	79.7	77.9	77.4	77.4
1990	79.2	78.6	76.9	76.3	75.2
1991	80.6	79.5	77.0	75.8	73.7
1992	80.6	79.2	76.6	74.4	72.1
1993	80.9	79.4	75.7	74.4	71.6
1994	79.9	78.7	74.5	74.4	71.2
1995	79.0	78.6	76.1	76.2	73.8
1996	76.3	75.8	72.9	72.9	70.9
1997	75.3	75.5	72.6	73.0	71.0
1998	72.1	69.2	71.3	68.1	65.4

Table 7(a) Percentage Correct, UK area. Percentage of events correctly forecast, based on Rain/No Rain criterion, as in Table 6(a).
NB:1998 results are for the 06Z run forecast, previous results are for combined 00Z and 12Z run forecasts.

	FORECAST PERIOD				
	0-6	6-12	12-18	18-24	24-30
1988	1.0	1.1	1.2	1.2	1.3
1989	1.0	1.1	1.2	1.2	1.3
1990	1.0	1.0	1.1	1.1	1.1
1991	0.9	1.1	1.2	1.3	1.3
1992	0.9	1.1	1.3	1.3	1.4
1993	1.0	1.2	1.4	1.4	1.6
1994	1.1	1.3	1.5	1.5	1.6
1995	1.3	1.3	1.5	1.4	1.5
1996	1.5	1.5	1.7	1.6	1.7
1997	1.6	1.6	1.7	1.6	1.7
1998	1.5	1.7	1.5	1.6	1.7

Table 7(c) Bias, UK area. Number of occasions on which rain was forecast as a ratio of the number of occasions on which rain was observed, as in Table 6(a).
NB:1998 results are for the 06Z run forecast, previous results are for combined 00Z and 12Z run forecasts.

TABLE 8: VERIFICATION OF MESOSCALE MODEL PRECIPITATION FORECAST

FORECAST PERIOD 0-6

FORECAST \ Observed	O	L	M	H	All
O	49.4	6.4	0.3	0.0	56.1
L	16.1	16.3	3.0	0.1	35.5
M	0.5	3.1	3.6	0.4	7.6
H	0.0	0.1	0.4	0.3	0.7
All	66.0	25.9	7.3	0.8	100.0

FORECAST PERIOD 6-12

FORECAST \ Observed	O	L	M	H	All
O	47.2	4.7	0.4	0.0	52.3
L	20.5	14.3	3.6	0.1	38.5
M	1.2	3.4	3.3	0.4	8.4
H	0.0	0.1	0.5	0.2	0.8
All	68.9	22.5	7.8	0.7	100.0

FORECAST PERIOD 12-18

FORECAST \ Observed	O	L	M	H	All
O	47.5	5.6	0.6	0.0	53.8
L	18.6	15.0	3.1	0.1	36.8
M	1.0	3.8	3.3	0.3	8.5
H	0.0	0.2	0.5	0.2	0.9
All	67.1	24.6	7.6	0.7	100.0

FORECAST PERIOD 18-24

FORECAST \ Observed	O	L	M	H	All
O	44.1	5.8	0.5	0.0	50.5
L	22.0	14.0	2.9	0.1	38.9
M	1.5	4.3	3.7	0.2	9.7
H	0.1	0.1	0.5	0.2	0.9
All	67.7	24.2	7.6	0.5	100.0

FORECAST PERIOD 24-30

FORECAST \ Observed	O	L	M	H	All
O	42.8	6.1	0.6	0.0	49.6
L	21.4	15.4	3.1	0.2	40.1
M	1.6	4.2	3.2	0.3	9.3
H	0.1	0.1	0.4	0.2	0.9
All	66.0	25.9	7.3	0.8	100.0

Table 8 UK area. Contingency tables for 1998 with frequencies averaged over selected reporting stations and expressed as percentages (06Z run data).
Key to precipitation classes:-
"O" = Nil pptn (less than 0.1 mm), "L" = Light (between 0.1 & 2.4 mm)
"M" = Moderate (between 2.4 & 10.4 mm), "H" = Heavy (10.4 mm or more)

TABLE 9: ANNUAL MEAN STATISTICS FOR THE UK MESOSCALE MODEL

VERIFICATION AGAINST OBSERVATIONS

	FORECAST PERIOD				
	0-6	6-12	12-18	18-24	24-30
1993	79.3	76.6	77.2	75.0	72.9
1994	78.5	75.0	74.6	70.7	71.3
1995	79.0	76.1	77.1	74.7	73.8
1996	78.0	73.9	72.9	68.9	68.5
1997	79.9	75.7	74.6	69.8	70.1
1998	76.7	73.1	74.1	70.1	70.0

Table 9(a) Precipitation: Percentage Correct. Percentage of events correctly forecast, based on Rain/No Rain criterion, as in Table 8 (06Z run data).

	FORECAST PERIOD				
	0-6	6-12	12-18	18-24	24-30
1993	1.04	1.40	1.19	1.33	1.36
1994	1.09	1.43	1.36	1.48	1.42
1995	1.18	1.48	1.32	1.41	1.37
1996	1.32	1.69	1.63	1.75	1.59
1997	1.26	1.62	1.60	1.80	1.63
1998	1.29	1.54	1.41	1.53	1.48

Table 9(b) Precipitation: Bias. Number of occasions on which rain was forecast as a ratio of the number of occasions on which rain was observed, as in Table 8 (06Z run data).

	MEAN ERROR (SURF)				RMS ERROR (SURF)			
	T+6	T+12	T+18	T+24	T+6	T+12	T+18	T+24
1993	-0.31	-0.27	-0.04	0.18	1.83	1.68	1.68	1.80
1994	-0.63	-0.42	0.17	0.30	1.83	1.74	1.68	1.71
1995	0.03	0.28	0.68	0.76	1.75	1.68	1.83	1.99
1996	-0.17	0.09	0.55	0.57	1.68	1.60	1.76	1.86
1997	-0.27	-0.01	0.44	0.50	1.66	1.52	1.66	1.79
1998	-0.40	-0.14	0.27	0.30	1.58	1.51	1.55	1.63

Table 9(c) Mean and Rms errors of 1.5m temperature forecasts (in degrees K) from the Mesoscale Model (06Z run data).

	MEAN ERROR				RMS ERROR			
	T+6	T+12	T+18	T+24	T+6	T+12	T+18	T+24
1993	-0.79	-0.48	0.11	0.03	2.73	2.80	2.93	2.81
1994	-0.01	0.57	1.17	0.88	2.33	2.53	3.00	2.81
1995	-0.42	-0.13	0.43	0.11	2.34	2.43	2.89	2.76
1996	-0.87	-0.16	0.31	0.10	2.41	2.46	2.74	2.63
1997	-0.57	-0.21	0.32	0.00	2.40	2.44	2.78	2.62
1998	-0.54	-0.16	0.20	-0.01	2.31	2.39	2.64	2.47

Table 9(d) Mean and Rms errors of total cloud amount forecasts (in oktas) from the Mesoscale Model (06Z run data).

	MEAN SPEED ERROR (SURF)				RMS VECTOR WIND ERROR (SURF)			
	T+6	T+12	T+18	T+24	T+6	T+12	T+18	T+24
1993	-1.30	-0.23	0.84	0.74	6.49	6.53	6.55	6.85
1994	-1.71	-0.62	0.21	0.25	6.74	6.74	6.95	7.25
1995	-1.60	-0.45	0.44	0.44	5.47	5.76	5.92	6.09
1996	-1.54	-0.40	0.56	0.59	5.28	5.34	5.54	5.83
1997	-1.38	-0.32	0.56	0.57	5.10	5.10	5.34	5.68
1998	-1.51	-0.37	0.49	0.44	5.18	5.28	5.35	5.69

Table 9(e) Mean speed and Rms vector wind errors of 10m wind forecasts (in knots) from the Mesoscale Model (06Z run data).

TABLE 10: 48-POINT VERIFICATION SCHEME

(Also see graphs in Figures 9a to 9d)

Year	Rms Ht Error	Rms Vector Wind Error	Ht Change Corr	Stretch Vector Corr	Ht/Ht Error Corr	F/C-Actual K.E. Equiv Wind	Rms F/C Ht Chge	Mean Ht Error	Rms Actual Wind
1957	45	16	0.67	0.63	-0.18	3	53	-8	24
1958	44	16	0.67	0.64	-0.18	5	55	-12	23
1959	46	17	0.67	0.67	-0.20	-4	57	-12	24
1960	43	16	0.67	0.66	-0.24	-4	51	-11	23
1961	45	17	0.66	0.62	-0.26	-5	53	-10	24
1962	45	17	0.70	0.65	-0.25	-7	59	-8	24
1963	43	16	0.70	0.66	-0.19	-4	53	-10	24
1964	42	15	0.70	0.65	-0.22	-3	54	-8	23
1965	44	16	0.71	0.66	-0.21	-5	59	-8	23
1966	44	16	0.69	0.65	-0.21	-5	57	-9	24
1967	44	16	0.72	0.67	-0.26	-7	55	-9	25
1968	43	15	0.67	0.67	-0.26	-6	48	-11	23
1969	42	15	0.69	0.66	-0.22	-4	51	-10	23
1970	42	16	0.70	0.63	-0.20	-4	55	-9	24
1971	43	16	0.66	0.64	-0.26	-5	53	-5	22
1972	43	16	0.66	0.67	-0.26	-5	56	-5	24
1973	42	16	0.70	0.63	-0.21	3	60	-5	23
1974	43	17	0.68	0.64	-0.27	-8	57	-5	25
1975	38	14	0.74	0.69	-0.26	-7	55	-7	23
1976	39	14	0.73	0.69	-0.26	-8	53	-6	23
1977	35	13	0.79	0.74	-0.25	-8	58	-5	24
1978	33	13	0.79	0.75	-0.21	-7	56	-4	24
1979	35	13	0.82	0.74	-0.14	-9	63	-8	24
1980	32	12	0.84	0.77	-0.19	-5	61	-11	23
1981	33	13	0.83	0.74	-0.21	-7	62	-9	24
1982	32	13	0.84	0.77	-0.11	-4	63	-6	25
1983	28	11	0.87	0.81	-0.07	1	67	-9	25
1984	27	11	0.86	0.80	-0.05	4	59	-8	23
1985	27	11	0.87	0.81	-0.05	5	56	-9	23
1986	29	12	0.88	0.82	-0.00	7	69	-13	26
1987	23	10	0.90	0.83	-0.01	5	60	-5	22
1988	22	10	0.90	0.85	-0.08	2	62	-4	24
1989	24	11	0.90	0.83	0.00	4	60	-7	24
1990	22	10	0.91	0.84	-0.03	2	61	-7	25
1991	22	10	0.91	0.85	0.04	6	63	-5	24
1992	23	11	0.91	0.82	0.05	7	68	-2	24
1993	20	10	0.92	0.84	0.07	7	62	-2	24
1994	20	11	0.93	0.86	0.08	8	60	-3	25
1995	19	10	0.93	0.84	-0.07	4	62	2	24
1996	18	10	0.92	0.86	0.01	3	60	3	23
1997	19	10	0.91	0.85	-0.03	2	60	5	23
1998	18	10	0.94	0.87	-0.09	0	62	5	24

Table 10(a) NMC T+24: Verification of NMC's 24-hour forecast of the geopotential height (in metres) and geostrophic wind (in knots) at 1000 hPa, valid at 00Z.

Year	Rms Ht Error	Rms Vector Wind Error	Ht Change Corr	Stretch Vector Corr	Ht/Ht Error Corr	F/C-Actual K.E. Equiv	Rms F/C Ht Chge	Mean Ht Error	Rms Actual Wind
1980	28	10	0.88	0.82	-0.25	-8	62	-9	23
1981	29	12	0.87	0.80	-0.28	-10	62	-8	24
1982	29	12	0.87	0.80	-0.20	-6	64	-5	25
1983	27	11	0.89	0.83	-0.01	7	68	-9	25
1984	27	11	0.89	0.82	0.03	6	63	-10	23
1985	25	10	0.90	0.85	0.03	7	61	-13	23
1986	28	11	0.91	0.85	0.06	8	73	-15	26
1987	23	10	0.92	0.85	-0.01	5	62	-3	22
1988	20	10	0.92	0.87	-0.06	0	63	-4	24
1989	21	10	0.92	0.86	-0.01	3	59	-7	24
1990	19	9	0.93	0.86	-0.04	1	61	-7	25
1991	19	9	0.93	0.87	0.06	5	63	-5	24
1992	20	10	0.93	0.87	0.10	6	66	-1	24
1993	18	9	0.94	0.88	0.13	8	70	-1	24
1994	19	9	0.94	0.88	0.21	8	71	-2	25
1995	17	9	0.95	0.88	-0.03	2	69	4	24
1996	17	9	0.93	0.89	0.04	3	61	4	23
1997	18	9	0.93	0.88	-0.01	2	60	6	23
1998	17	9	0.95	0.88	-0.03	1	62	6	24

Table 10(b) Limited Area T+24: Verification of the Limited Area Model 24-hour forecast of the geopotential height (in metres) and geostrophic wind (in knots) at 1000 hPa, valid at 00Z.

Year	Rms Ht Error	Rms Vector Wind Error	Ht Change Corr	Stretch Vector Corr	Ht/Ht Error Corr	F/C-Actual K.E. Equiv Wind	Rms F/C Ht Chge	Mean Ht Error	Rms Actual Wind
1968	37	13	0.77	0.72	-0.43	-11	47	-14	23
1969	37	13	0.79	0.73	-0.43	-11	49	-14	23
1970	38	13	0.80	0.71	-0.36	-11	53	-16	24
1971	38	13	0.78	0.73	-0.40	-11	50	-16	22
1972	36	13	0.77	0.73	-0.41	-11	50	-10	24
1973	33	12	0.82	0.74	-0.44	-10	58	-12	23
1974	36	14	0.80	0.74	-0.43	-13	57	-2	25
1975	32	13	0.82	0.74	-0.29	-9	55	-9	23
1976	33	12	0.81	0.74	-0.38	-11	52	-4	23
1977	29	12	0.84	0.78	-0.40	-12	56	2	24
1978	28	11	0.85	0.82	-0.42	-11	54	4	24
1979	27	11	0.87	0.80	-0.40	-12	59	3	24
1980	24	10	0.88	0.82	-0.44	-12	57	0	23
1981	26	12	0.87	0.80	-0.45	-12	57	0	24
1982	26	11	0.88	0.81	-0.39	-12	61	2	25
1983	22	10	0.91	0.85	-0.16	-6	65	-3	25
1984	22	10	0.89	0.84	-0.02	3	60	-1	23
1985	20	9	0.91	0.86	-0.08	4	56	3	23
1986	22	10	0.91	0.85	-0.03	5	59	0	26
1987	19	9	0.92	0.85	-0.06	4	60	1	26
1988	20	10	0.92	0.87	-0.13	-3	61	3	24
1989	19	9	0.92	0.86	-0.06	-3	58	2	24
1990	19	9	0.95	0.86	-0.08	-3	59	2	25
1991	17	9	0.93	0.87	-0.01	0	63	0	24
1992	18	9	0.94	0.87	0.00	-1	63	0	24
1993	17	9	0.94	0.88	0.06	4	59	0	23
1994	18	9	0.94	0.89	0.10	5	59	-1	25
1995	15	8	0.95	0.89	-0.08	-1	61	4	24
1996	16	8	0.94	0.89	-0.06	0	60	4	23
1997	17	9	0.93	0.88	-0.10	-1	59	5	23
1998	16	9	0.95	0.88	-0.06	0	61	5	24

Table 10(c) Global T+24: Verification of the Global Model 24-hour forecast of the geopotential height (in metres) and geostrophic wind (in knots) at 1000 hPa, valid at 00Z.

Year	Rms Ht Error	Ht Vector Wind Error	Ht Change Corr	Stretch Vector Corr	Ht/Ht Error Corr	F/C-Actual K.E. Equiv	Rms F/C Ht Chge	Mean Ht Error	Rms Actual Wind
1969	66	18	0.50	0.52	-0.49	-11	60	-35	23
1970	67	19	0.52	0.49	-0.49	-11	64	-37	24
1977	67	18	0.48	0.49	-0.48	-11	61	-36	22
1972	60	18	0.49	0.55	-0.48	-12	54	-21	24
1973	57	18	0.74	0.52	-0.50	-11	84	-20	23
1974	60	19	0.70	0.50	-0.52	-14	79	-4	25
1975	55	18	0.73	0.52	-0.41	-10	80	-17	23
1976	59	17	0.72	0.52	-0.48	-13	77	-13	23
1977	51	16	0.78	0.59	-0.49	-14	81	-13	24
1978	45	15	0.79	0.66	-0.47	-13	74	-3	24
1979	45	16	0.81	0.57	-0.44	-14	83	-4	24
1980	43	15	0.83	0.66	-0.47	-13	81	-13	23
1981	46	16	0.81	0.62	-0.50	-15	78	-12	24
1982	41	15	0.83	0.66	-0.38	-12	84	5	25
1983	34	13	0.89	0.76	-0.13	-4	90	-8	25
1984	35	14	0.86	0.74	-0.01	6	81	-5	23
1985	32	14	0.87	0.74	-0.16	4	77	0	23
1986	34	14	0.87	0.74	-0.09	6	88	-2	26
1987	32	13	0.88	0.73	-0.11	4	83	-1	22
1988	31	13	0.89	0.77	-0.15	-3	78	1	24
1989	29	13	0.87	0.76	-0.10	0	79	1	24
1990	31	13	0.87	0.76	-0.14	-4	81	3	25
1991	29	12	0.90	0.77	-0.06	2	85	-1	24
1992	29	12	0.91	0.77	-0.04	3	86	2	24
1993	27	12	0.92	0.80	0.02	3	82	-1	24
1994	31	13	0.91	0.80	0.09	9	89	-5	25
1995	25	11	0.93	0.80	-0.08	0	87	4	24
1996	26	11	0.92	0.82	-0.10	0	84	6	23
1997	26	11	0.93	0.81	-0.15	-1	84	9	23
1998	25	12	0.93	0.81	-0.07	1	85	5	24

Table 10(d) Global T+48: Verification of the Global Model 48-hour forecast of the geopotential height (in metres) and geostrophic wind (in knots) at 1000 hPa, valid at 00Z.

Year	Rms Ht Error	Rms Vector Wind Error	Ht Change Corr	Stretch Vector Corr	Ht/Ht Error Corr	F/C-Actual K.E. Equiv Wind	Rms F/C Ht Chge	Mean Ht Error	Rms Actual Wind
1969	88	21	0.33	0.37	-0.55	-12	78	-50	23
1970	92	22	0.33	0.30	-0.50	-11	84	-54	24
1971	93	22	0.31	0.30	-0.57	-12	83	-53	22
1972	80	22	0.32	0.40	-0.53	-13	69	-28	24
1973	78	22	0.65	0.36	-0.54	-11	98	-23	23
1974	78	23	0.62	0.31	-0.58	-15	92	-4	25
1975	76	22	0.65	0.37	-0.47	-9	97	-21	23
1976	77	20	0.65	0.37	-0.54	-13	93	-20	23
1977	67	19	0.72	0.44	-0.58	-16	95	-22	24
1978	58	18	0.71	0.49	-0.54	-15	84	0	24
1979	61	19	0.74	0.47	-0.50	-15	95	2	24
1980	58	18	0.78	0.52	-0.53	-14	89	-10	23
1981	60	19	0.74	0.47	-0.56	-16	87	-7	24
1982	55	18	0.78	0.53	-0.42	-12	96	-3	25
1983	48	16	0.83	0.65	-0.17	3	103	-12	25
1984	48	17	0.79	0.62	-0.09	7	100	-11	23
1985	46	17	0.80	0.61	-0.22	6	89	1	23
1986	45	17	0.83	0.63	-0.20	8	97	0	26
1987	44	16	0.83	0.62	-0.21	5	95	1	22
1988	44	19	0.84	0.65	-0.26	-6	99	3	24
1989	38	16	0.83	0.59	-0.16	-2	93	2	24
1990	44	16	0.84	0.58	-0.21	-5	93	4	25
1991	43	16	0.85	0.64	-0.15	1	98	-1	24
1992	41	16	0.85	0.65	-0.14	0	96	3	24
1993	40	15	0.87	0.68	-0.07	3	95	-3	24
1994	43	16	0.87	0.69	0.03	9	101	-5	25
1995	36	15	0.88	0.68	-0.17	0	101	5	24
1996	36	14	0.89	0.72	-0.19	0	98	7	23
1997	36	14	0.88	0.71	-0.20	-1	98	11	23
1998	35	15	0.89	0.71	-0.13	1	97	4	24

Table 10(e) Global T+72: Verification of the Global Model 72-hour forecast of the geopotential height (in metres) and geostrophic wind (in knots) at 1000 hPa, valid at 00Z.

TABLE 11: ANNUAL MEAN STATISTICS FOR THE GLOBAL WAVE-MODEL

VERIFICATION AGAINST OBSERVATIONS

	MEAN ERROR			RMS ERROR		
	T+24	T+48	T+72	T+24	T+48	T+72
1988	1.2	1.2	1.2	6.0	7.0	7.8
1989	1.2	1.2	1.2	5.8	7.0	7.8
1990	0.8	1.0	0.8	5.6	6.6	7.2
1991	1.0	1.2	1.4	5.2	6.2	7.2
1992	0.4	0.8	1.0	5.1	6.0	6.8
1993	0.8	1.0	1.2	5.1	5.8	6.8
1994	0.8	1.4	1.4	5.1	6.0	6.8
1995	1.0	1.2	1.2	5.1	6.0	6.8
1996	1.2	1.3	1.5	5.1	5.8	6.6
1997	1.0	1.2	1.2	4.9	5.8	6.6
1998	1.4	1.6	1.6	4.9	5.6	6.4

Table 11(a) Mean and Rms errors of wind speed forecasts used as input for the Global Wave Model (in knots).

	MEAN ERROR			RMS ERROR		
	T+24	T+48	T+72	T+24	T+48	T+72
1988	0.1	0.1	0.0	0.9	1.0	1.1
1989	-0.1	0.0	0.0	0.9	1.0	1.1
1990	-0.1	-0.1	-1.0	0.8	0.9	1.1
1991	-0.3	-0.2	-0.2	0.9	0.9	1.0
1992	-0.4	-0.4	-0.4	1.0	1.1	1.2
1993	-0.2	-0.2	-0.2	0.8	0.9	1.0
1994	-0.3	-0.2	-0.1	0.8	0.9	1.0
1995	-0.1	0.0	0.0	0.7	0.8	0.9
1996	0.1	0.1	0.1	0.6	0.8	0.9
1997	0.1	0.1	0.1	0.6	0.7	0.8
1998	0.1	0.2	0.2	0.6	0.7	0.9

Table 11(b) Mean and Rms errors of wave height forecasts from the Global Wave Model (in metres).

	MEAN ERROR			RMS ERROR		
	T+24	T+48	T+72	T+24	T+48	T+72
1988	-0.7	-0.6	-0.7	2.4	2.6	2.8
1989	-0.3	-0.1	-0.1	2.5	2.7	2.9
1990	-0.1	0.0	0.1	2.4	2.6	2.7
1991	***	***	***	***	***	***
1992	-0.2	-0.3	-0.4	3.3	3.9	4.0
1993	0.3	0.1	0.0	2.6	2.7	2.8
1994	0.3	0.1	0.1	2.6	2.7	2.8
1995	0.6	0.5	0.5	2.5	2.7	2.8
1996	0.9	0.8	0.7	2.7	2.8	2.9
1997	0.9	0.8	0.7	2.6	2.7	2.8
1998	0.8	0.8	0.7	2.5	2.7	2.8

Table 11(c) Mean and Rms errors of wave period forecasts from the Global Wave Model (in seconds).

TABLE 12: ANNUAL MEAN STATISTICS FOR THE EUROPEAN WAVE-MODEL

VERIFICATION AGAINST OBSERVATIONS

	MEAN ERROR			RMS ERROR		
	T+12	T+24	T+36	T+12	T+24	T+36
1988	0.8	1.0	1.0	5.2	6.0	7.0
1989	1.0	1.2	1.4	5.2	5.8	6.8
1990	1.2	1.2	1.4	5.2	5.8	6.4
1991	0.8	1.2	1.6	4.9	5.4	6.2
1992	0.8	1.4	1.6	5.2	6.0	6.8
1993	0.7	1.2	1.4	5.1	5.8	6.6
1994	1.4	1.6	2.1	5.1	5.8	6.6
1995	1.4	1.5	1.9	4.7	5.4	6.0
1996	1.4	1.4	1.7	4.7	5.2	5.6
1997	1.4	1.2	1.7	4.5	5.2	5.6
1998	1.4	1.2	1.7	4.7	5.6	6.2

Table 12(a) Mean and Rms errors of wind speed forecasts used as input for the European Wave Model (in knots).

	MEAN ERROR			RMS ERROR		
	T+12	T+24	T+36	T+12	T+24	T+36
1988	0.1	0.1	0.1	0.8	0.9	0.9
1989	0.2	0.2	0.3	0.9	0.9	1.0
1990	0.0	0.0	0.0	0.9	0.9	1.0
1991	0.1	0.1	0.1	1.0	1.0	1.1
1992	-0.2	-0.1	0.0	0.9	0.9	1.0
1993	-0.2	-0.2	-0.1	0.9	0.9	1.0
1994	-0.2	-0.1	0.0	0.8	0.8	0.9
1995	0.0	0.0	0.1	0.7	0.8	0.8
1996	0.1	0.1	0.2	0.6	0.7	0.7
1997	0.1	0.1	0.2	0.6	0.7	0.7
1998	0.1	0.1	0.2	0.6	0.7	0.8

Table 12(b) Mean and Rms errors of wave height forecasts from the European Wave Model (in metres).

	MEAN ERROR			RMS ERROR		
	T+12	T+24	T+36	T+12	T+24	T+36
1988	-0.3	-0.3	-0.3	1.5	1.6	1.6
1989	-0.1	0.0	0.0	1.6	1.6	1.7
1990	-0.2	-0.2	-0.2	1.3	1.3	1.4
1991	-0.3	-0.3	-0.2	1.6	1.6	1.6
1992	-0.4	-0.3	-0.2	1.9	1.9	1.9
1993	-0.4	-0.3	-0.3	1.9	1.9	2.0
1994	0.0	0.0	0.0	1.1	1.4	1.5
1995	-0.6	-0.5	-0.5	1.6	2.0	2.0
1996	-0.4	-0.3	-0.3	1.4	1.5	1.5
1997	-0.2	-0.2	-0.2	1.3	1.3	1.3
1998	-0.3	-0.2	-0.3	1.3	1.3	1.3

Table 12(c) Mean and Rms errors of wave period forecasts from the European Wave Model (in seconds).

FIGURE 3. VERIFICATION AGAINST OBSERVATIONS - AREA 2

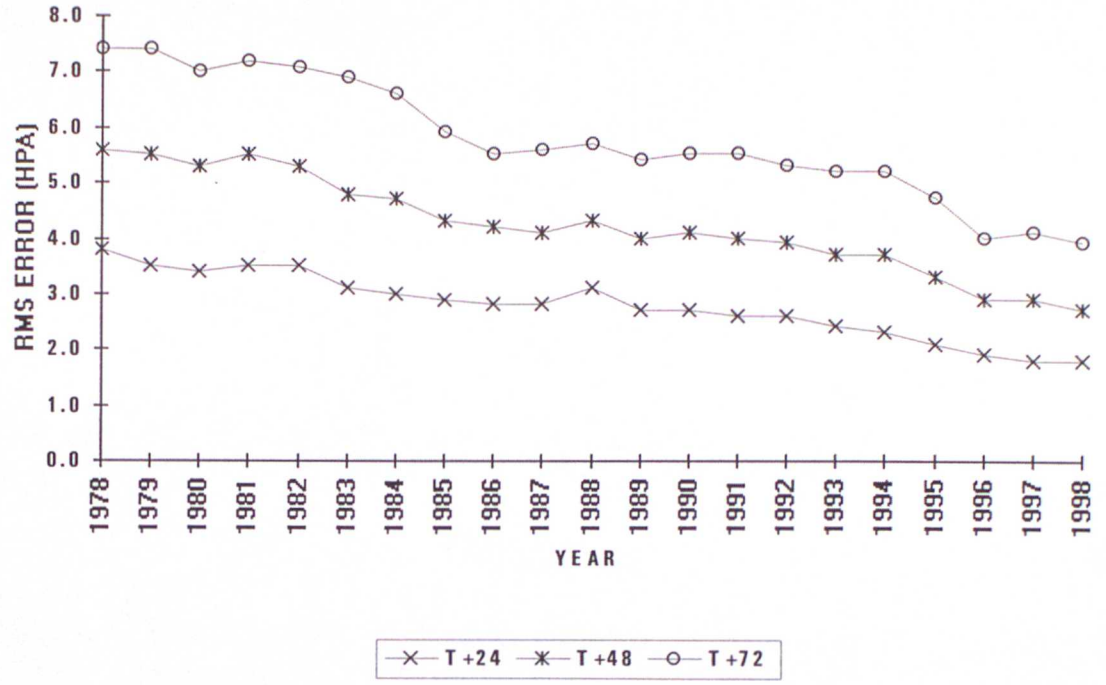

Figure 3(a) Rms error of PMSL

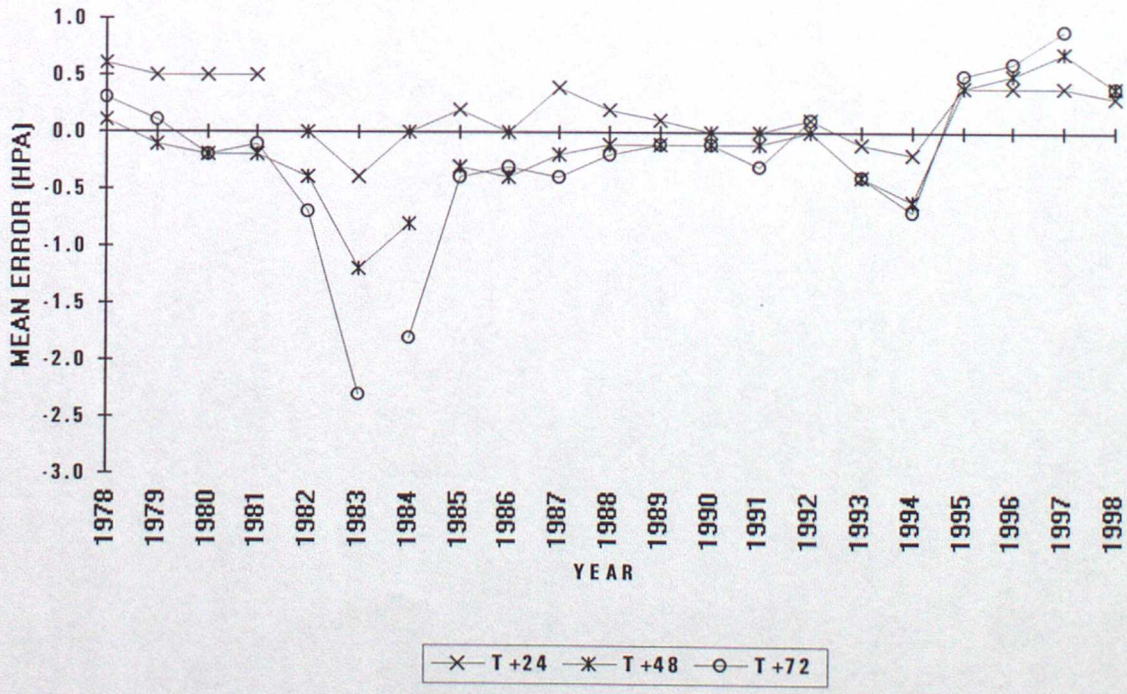

Figure 3(b) Mean error of PMSL

FIGURE 4. VERIFICATION AGAINST ANALYSES - AREA 2

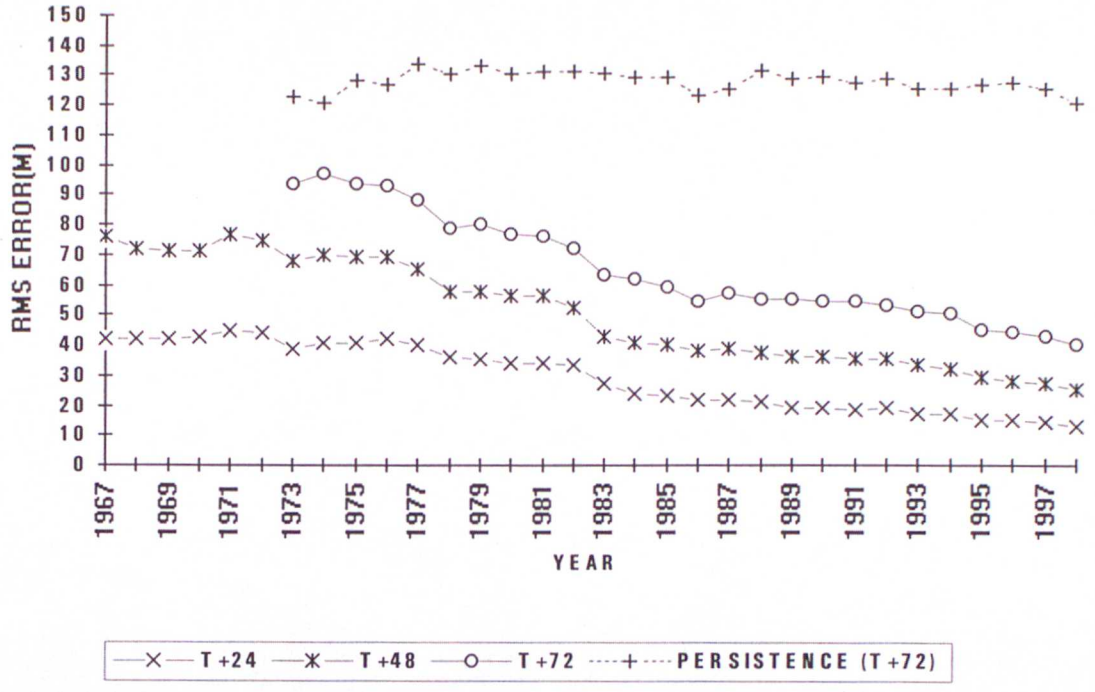

Figure 4(a) Rms error of 500 hPa height

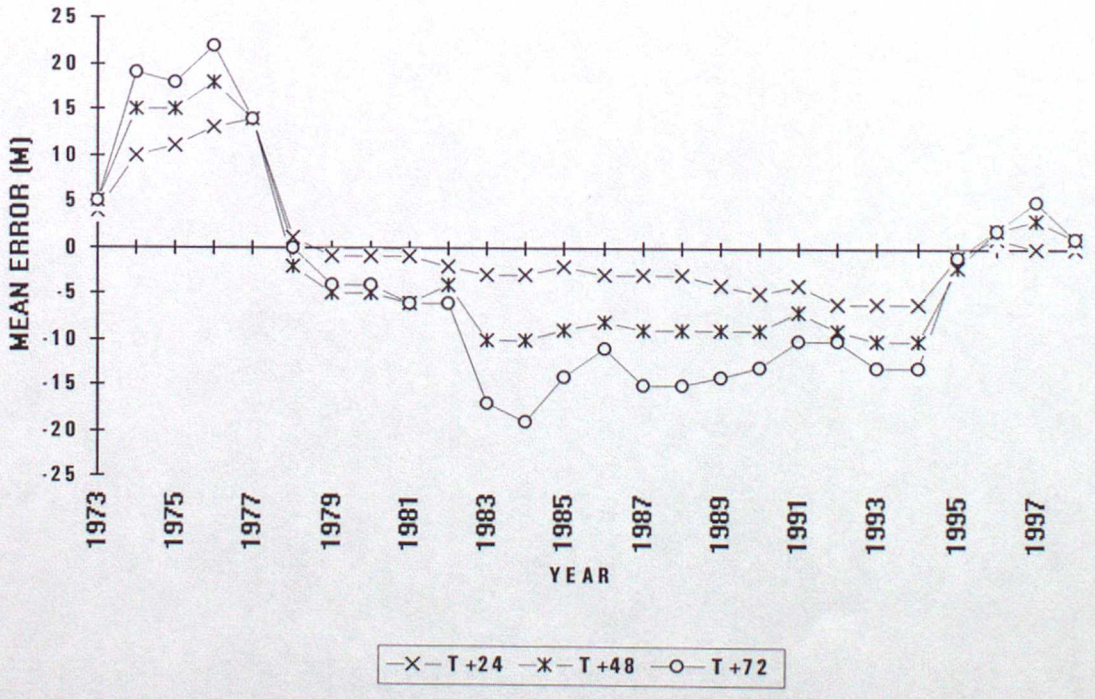

Figure 4(b) Mean error of 500 hPa height

FIGURE 5. VERIFICATION AGAINST ANALYSES - AREA 2

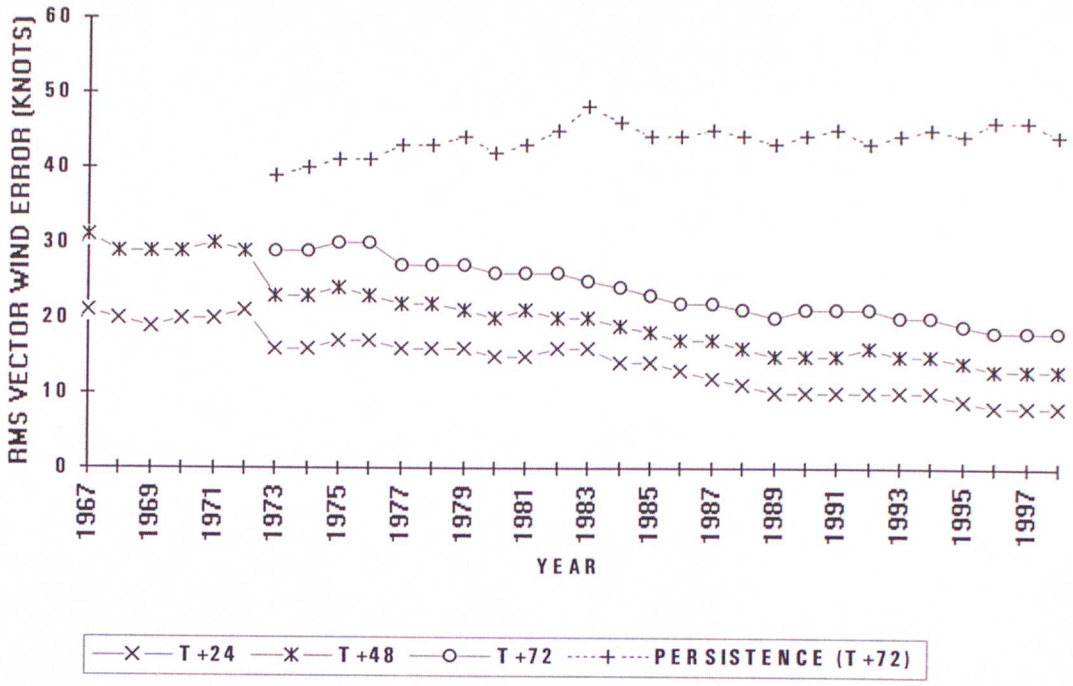

Figure 5(a) Rms vector wind error at 200 hPa

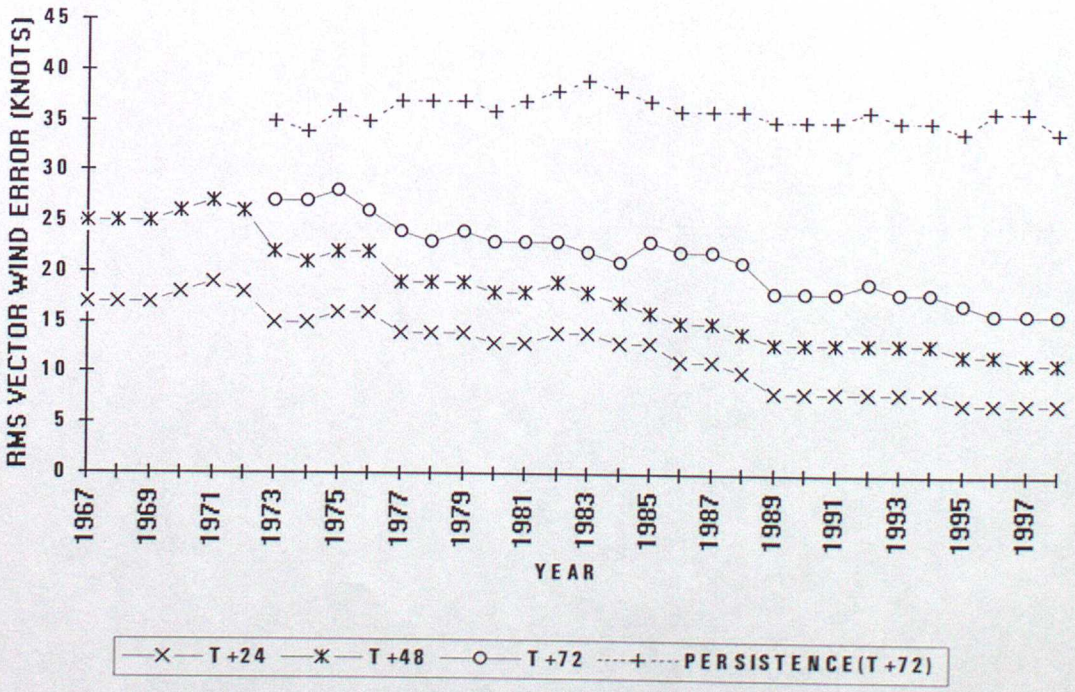

Figure 5(b) Rms vector wind error at 500 hPa

FIGURE 6. VERIFICATION AGAINST ANALYSES - NORTHERN HEMISPHERE

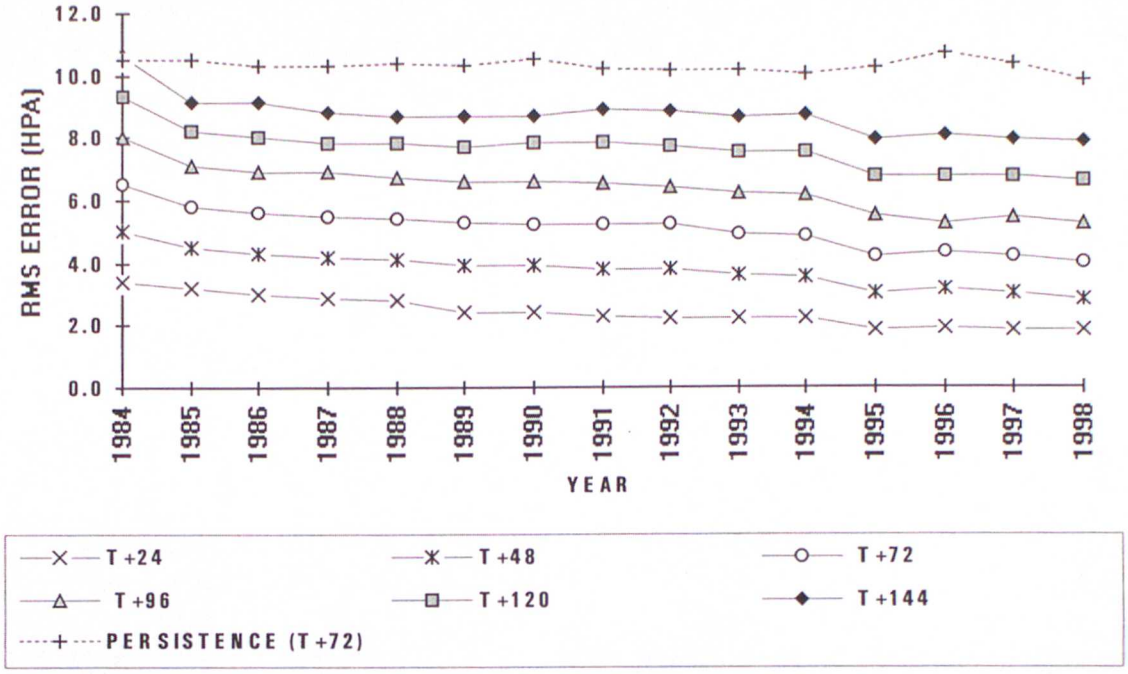

Figure 6(a) Rms error of PMSL

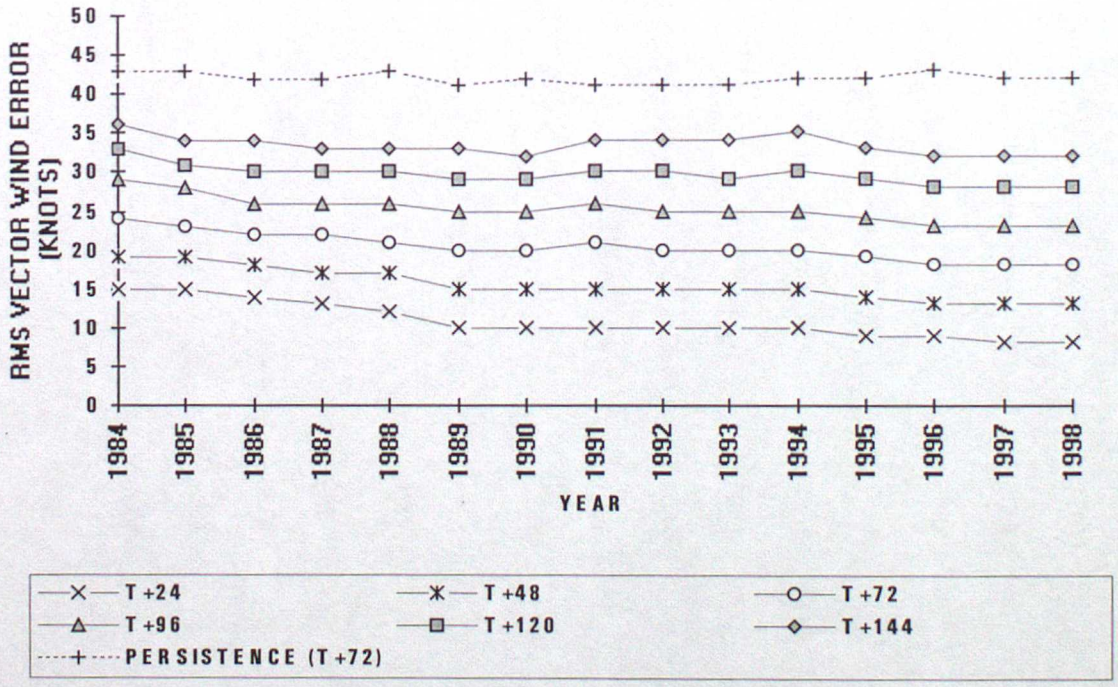

Figure 6(b) Rms vector wind error at 200 hPa

FIGURE 7. VERIFICATION AGAINST ANALYSES - TROPICS

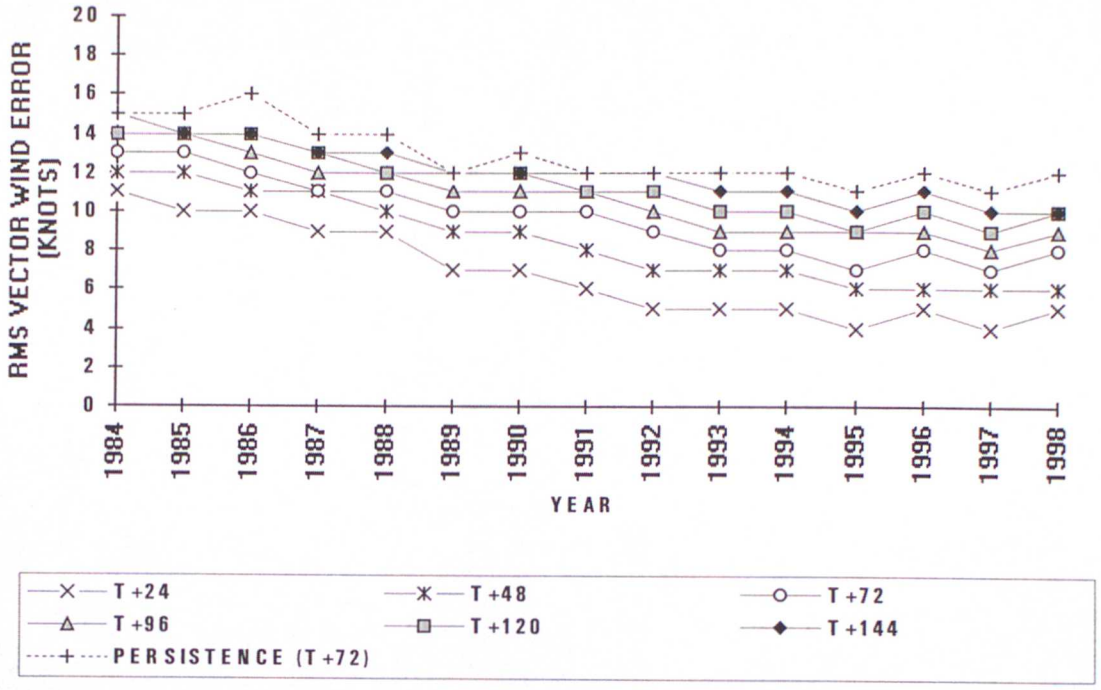

Figure 7(a) Rms vector wind error at 850 hPa

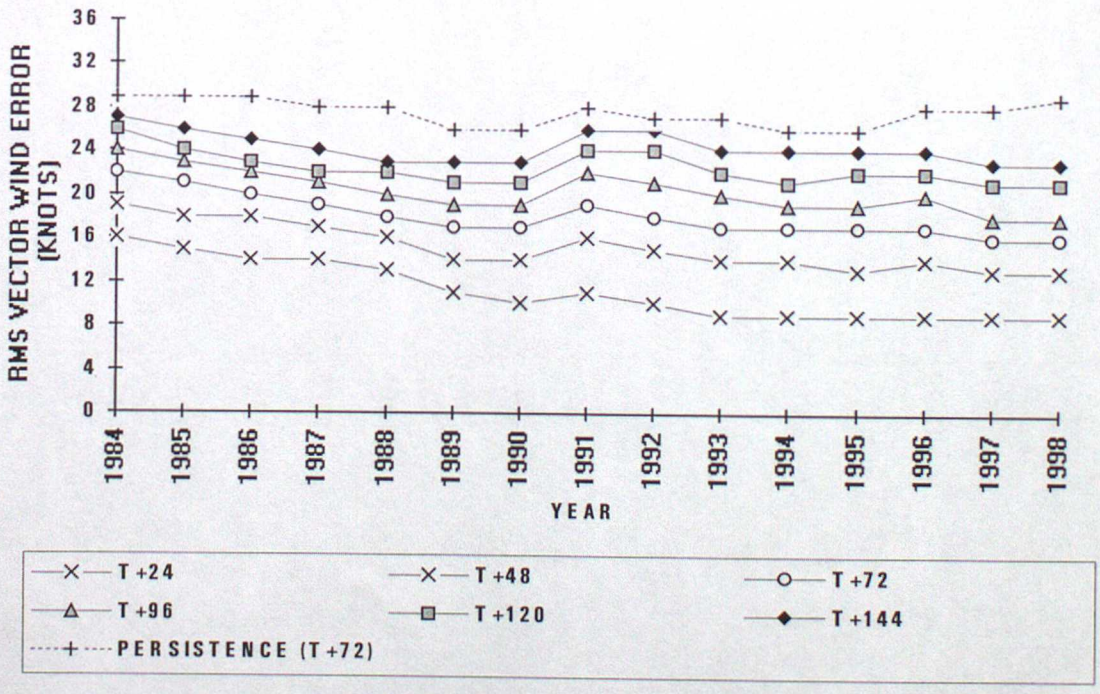

Figure 7(b) Rms vector wind error at 200 hPa

FIGURE 8. VERIFICATION AGAINST ANALYSES - SOUTHERN HEMISPHERE

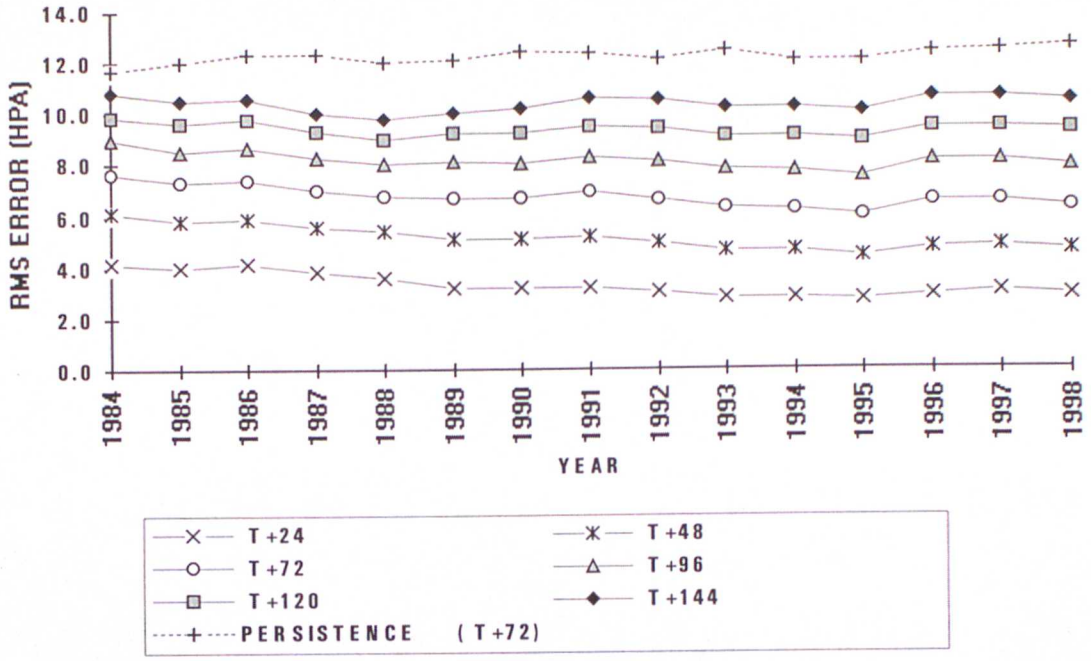

Figure 8(a) Rms error of PMSL

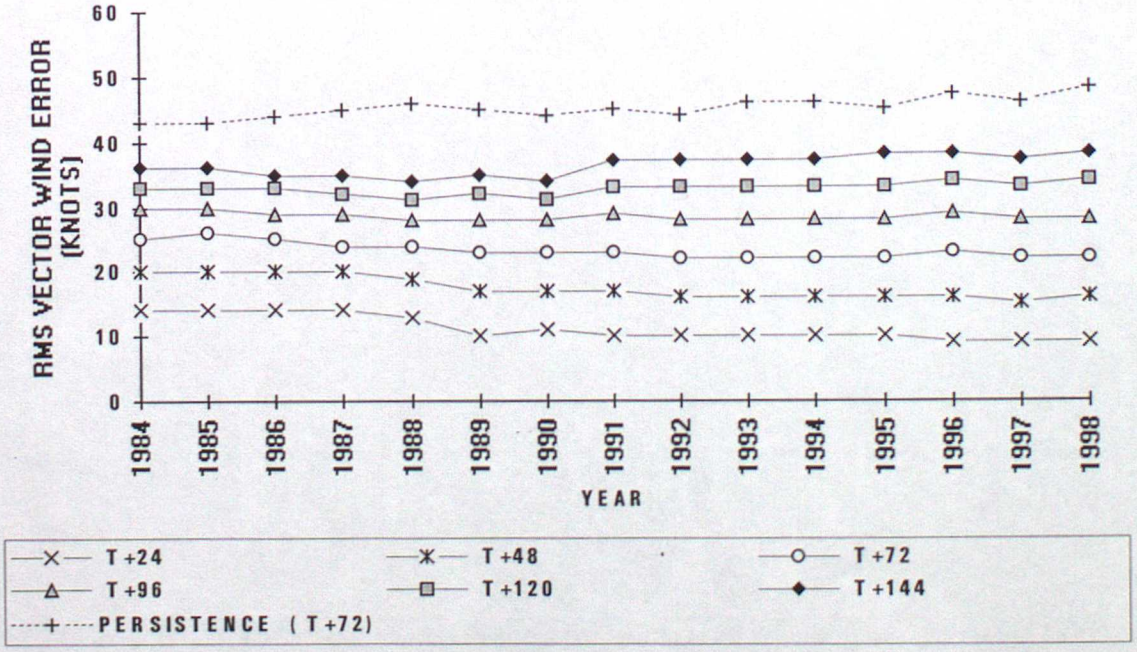

Figure 8(b) Rms vector wind error at 200 hPa

FIGURE 9. 48-POINT VERIFICATION SCHEME

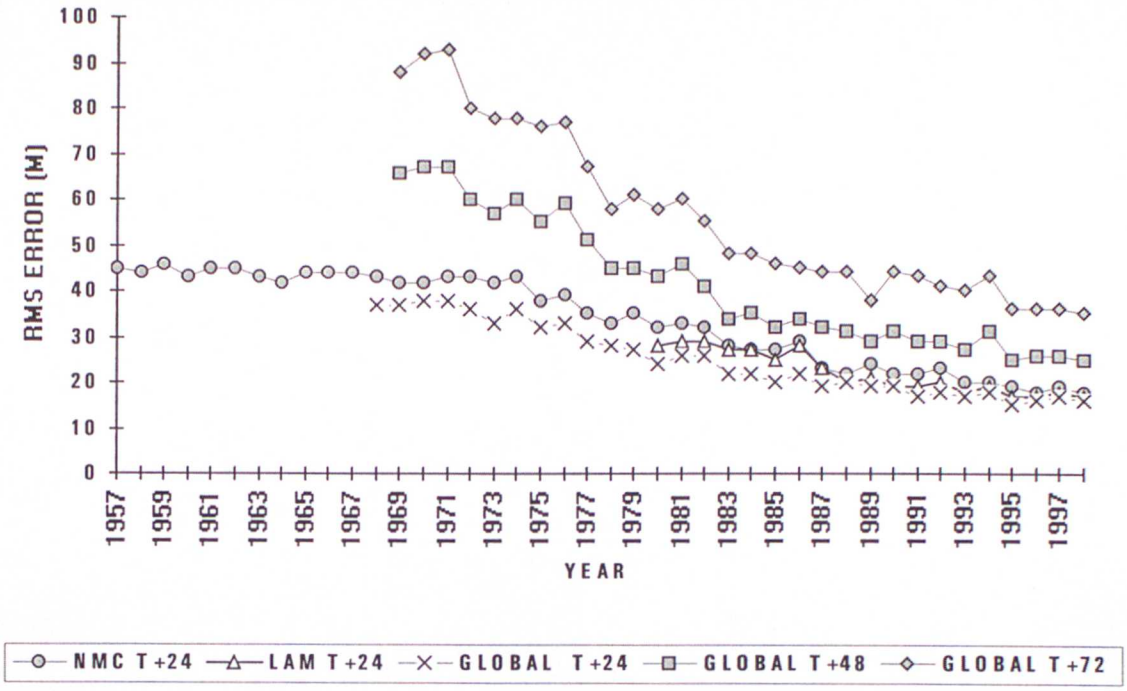

Figure 9(a) Rms error of 1000 hPa height

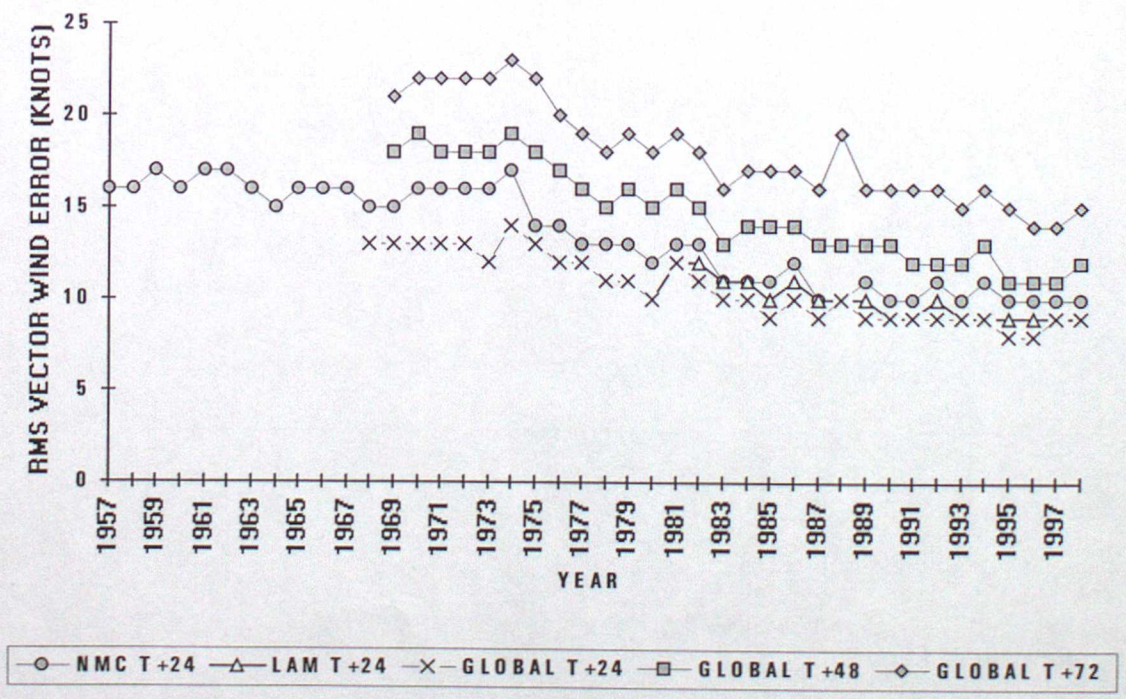

Figure 9(b) Rms vector wind error at 1000 hPa

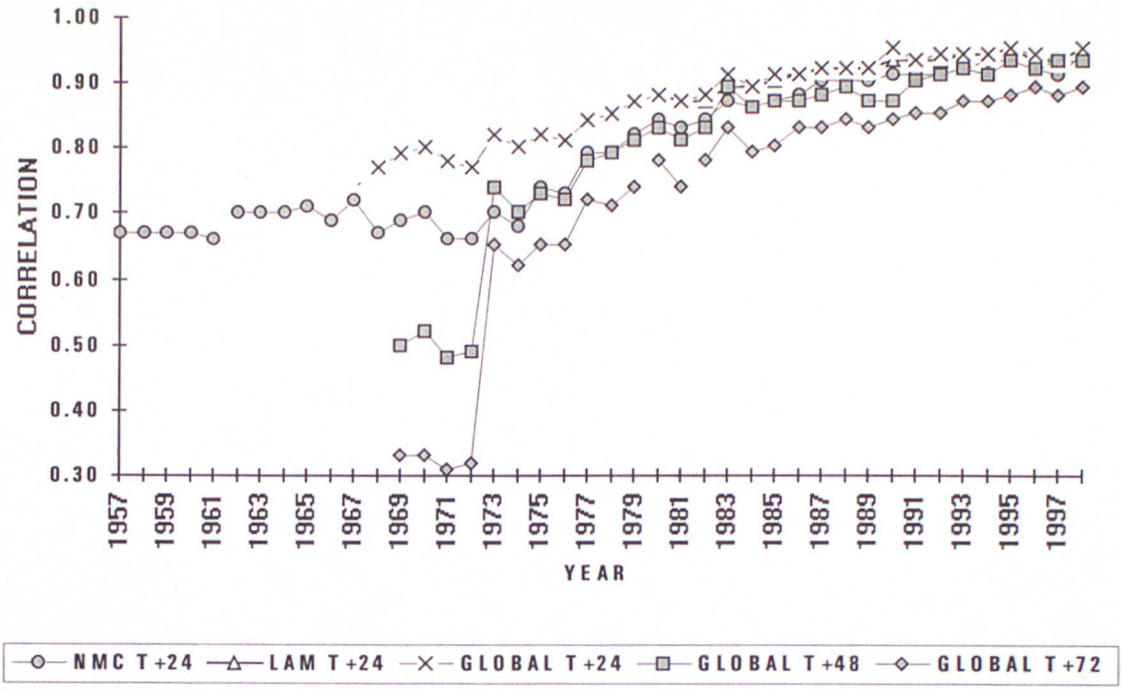

Figure 9(c) Height change correlation at 1000 hPa

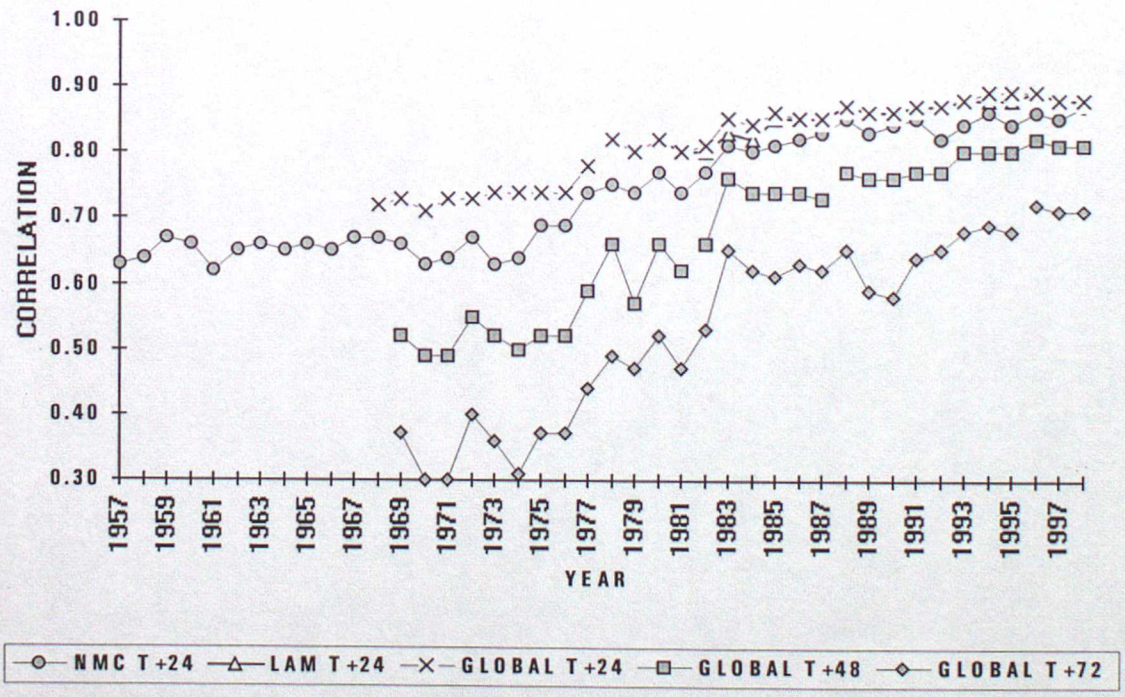

Figure 9(d) Wind stretch vector correlation at 1000 hPa